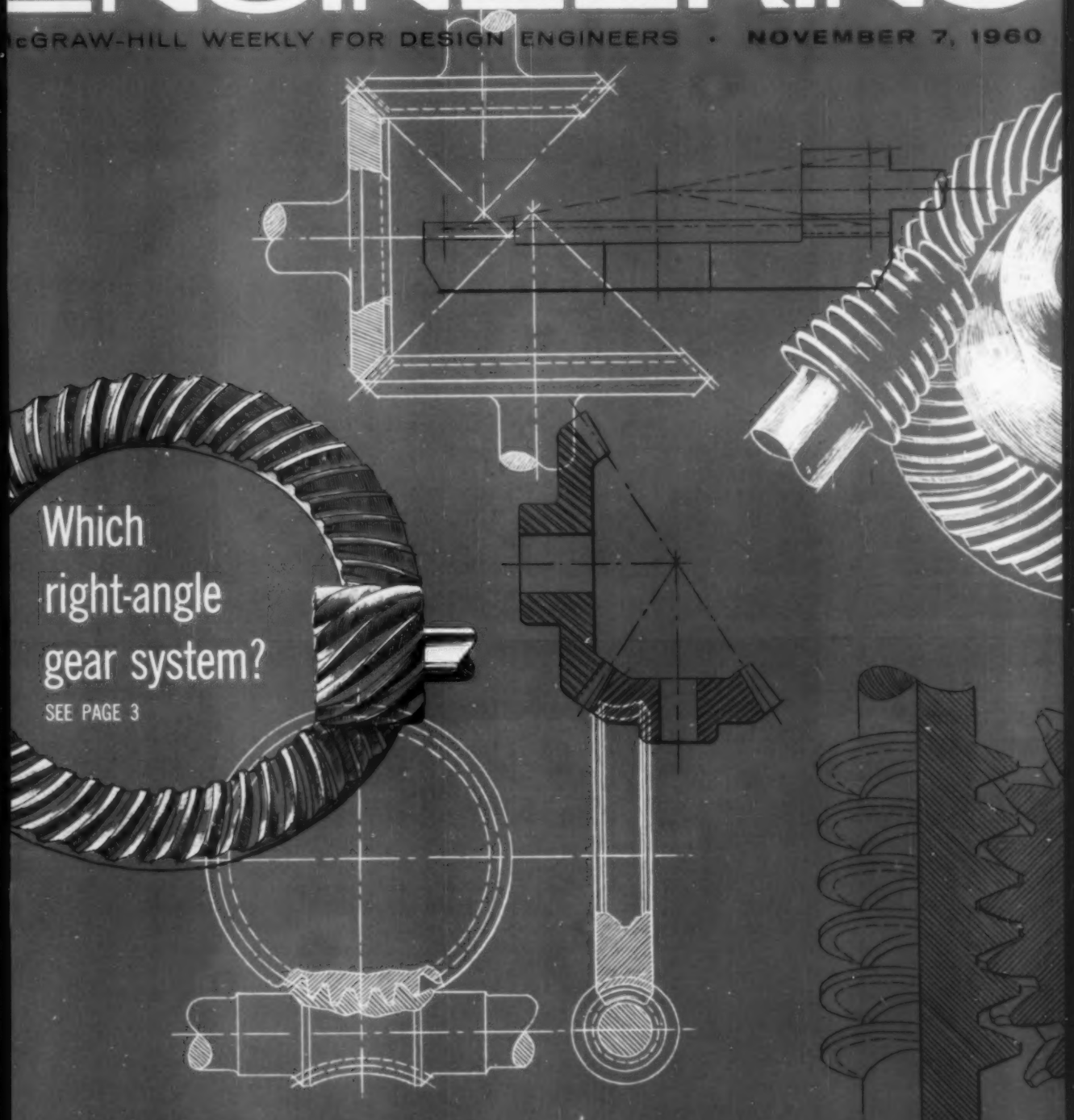
PRICE 50 CENTS

PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS · NOVEMBER 7, 1960



Which right-angle gear system?

SEE PAGE 3

WHAT CAPACITANCE TRANSDUCERS HAVE TO OFFER . . . PAGE 70
HOW TO GET MORE FROM YOUR SLIDERULE . . . PAGE 73
SECTION MODULUS CHARTS TO FIND BEAM DIMENSIONS . . . PAGE 77

"I want a 100,000 mile wheel seal," said truckmaker

"Here's Scotseal," said C/R

Premature wheel oil seal failure—often within the warranty period—was plaguing a major truck manufacturer. This was costly. One seal replacement took three hours labor and three hours tractor downtime—important money to the maker, dealer and buyer. Then C/R found an answer to the problem. A unique, new design called the C/R Scotseal* was submitted and tested . . . then tested again and again. First result: C/R Scotseals repeatedly ran 100,000 miles and more with no sign of failure. Second result: they're approved now for every truck tractor this manufacturer makes.

Just why does this seal go 100,000 miles? C/R developed a special, ideal sealing surface and made it integral with the seal. The lip runs on this surface, *not on the shaft or bore*. In operation, centrifugal force creates positive, constant contact for leak-free performance. Also, the seal lip is completely encased and pre-lubricated, protecting it against damage in handling and assembly. This remarkable seal merits your consideration wherever high production runs are involved; where oil retention is difficult; and where equipment downtime and replacement costs are critical. The savings it can afford you and your customers may far outweigh the additional cost of this top-quality seal.

Write for your copy of C/R Scotseal Bulletin SS-100.*

CHICAGO RAWHIDE MANUFACTURING COMPANY

OIL SEAL DIVISION: 1237 ELSTON AVENUE • CHICAGO 22, ILLINOIS
Offices in 55 principal cities. See your telephone book.
In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario
Export Sales: Geon International Corp., Great Neck, New York

C/R Products: C/R Shaft & End Face Seals • Sirvene (synthetic rubber) molded pliable parts
Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears.

C/R

*Reg. U. S. Pat. Off.

CIRCLE 201 ON READER SERVICE CARD

PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS

November 7, 1960 Vol. 31, No. 46

FEATURED:

DEPARTMENTS:

INTERESTING TO NOTE 3
COMING NEXT WEEK 4
DEVELOPMENTS TO WATCH 6
WHAT'S NEW IN RESEARCH 9
FROM WASHINGTON 12
THE ENGINEERING WEEK 15
POINTS OF VIEW 24
READER TO EDITOR 28
COMING EVENTS 29
FYI PERSONAL 32
HORIZONS 53
SIGNIFICANT COMPONENTS 80
DESIGN LITERATURE 95
REPRINTS 102
ADVERTISERS INDEX 106
READER SERVICE CARDS 109

WHICH RIGHT-ANGLE GEAR SYSTEM? . . . R C Bryant and D W Dudley
A detailed guide to the 16 types that are now available 55

WHAT CAPACITANCE TRANSDUCERS HAVE TO OFFER . . . J R McDermott
This article brings you up to date on their pros and cons 70

GET MORE FROM YOUR SLIDERULE . . . C J Lynch
Thirteen examples show quick ways to handle variety of problems 73

FINDS BEAM DIMENSIONS FASTER . . . L De Monge
Section modulus charts are the key 77

FIELDS OF INTEREST REPRESENTED IN DEPARTMENTS:

MATERIALS:
New polymers show outstanding dielectric properties 8
Fluorine plastic lubricates vacuum system 9
Teflon film can be cemented with common adhesives 80

MECHANICAL:
New seals for fluids designed by British 6
Random selection "guaranteed" by this machine 8
Hydraulic-actuator study highlights unsolved problems 9
Vernier device regulates pneumatic-system pressure 80

ELECTRICAL:
Multi-element thermal transducers for transfer functions 6
Transducers in the lab 9
Block-type reader scans eight characters at a time 80

PRODUCT DESIGN:
Batteries trigger target pistol 67
Snap-on engine fits assortment of implements 68

PROCESSES:
Carbide's compressive strength boosted by new treatment 6
Improved aluminizing process claimed by Air Force 8

GENERAL:
Radiotelescope 2 years behind schedule 12
Future product needs listed by space industry 15
Paris auto show presents new pump, advanced styling 20

lower your cost of possession

2 Nickel Alloy Steels provide

A simple plan to save money by Steel Standardization

How many types of steel do you normally use?

Chances are you should examine your needs for alloy steel to see how many can be satisfied with just two types, 4340 through-hardening and 4620 carburizing.

You are likely to find that most of your engineering requirements can be met with confidence when you *standardize* on these two general-purpose steels.

You simplify inventory and materials-handling. You save money in purchasing and production, too.

• 4340 stands alone among medium-carbon steels in its ability to provide maximum strength, ductility, toughness and resistance to fatigue in parts of medium to heavy section.

• 4620 is a carburizing type that has consistently proved itself the ideal steel for a wide variety of carburized parts. 4620 is easy to carburize and has a minimum tendency toward distortion in heat treatment.

Available From Steel Service Centers Both 4340 and 4620 are stocked by Steel Service Centers from coast to coast, ready for off-the-shelf delivery in a variety of sizes.

When you have carried your standardization plan as far as you can and you still have specialized needs to fill, the right nickel steels are available to give you extra performance or even lower costs.

For a buyer's guide to Steel Service Centers that stock 4340 and 4620, and other nickel-containing grades, simply write Inco.

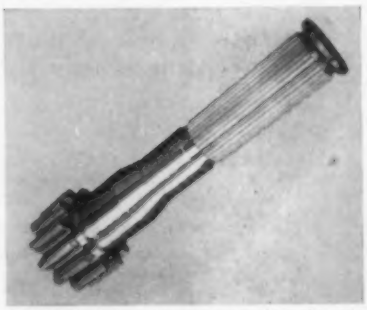
INCO TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

STEEL SERVICE CENTER INSTITUTE

Holding the Shippingport nuclear reactor's top head to its shell section is a job performed by 42 studs of AISI 4340. This through-hardening nickel steel provides essential strength and toughness.

Power-packed tractor features unique drive mechanism composed of regular gear transmission, clutch and torque converter with lock-up, utilizes nickel alloy steels in more than 25 components.



Swing shaft for giant power shovel made from 4340 nickel alloy steel for strength and toughness to take shock-loading in stride. This 9"-diameter, 36"-long shaft of 4340 nickel alloy steel transmits tremendous torque to a giant ring gear.

Sustained accuracy is assured in this heavy-duty milling machine by spindle and gear components of AISI 4340 and 4620 nickel alloy steels. They provide needed strength and wear resistance.

INTERESTING TO NOTE

On our cover—A pageful of right-angle gear drives. Gear designers today rely strongly on the works of mathematicians (see article, page 55) but this wasn't always the case. In the past, astronomers contributed a great deal to the understanding of gears and their applications. It was found in Ptolemy's time that many forces affecting the motion of planets were likewise applicable to certain gears. The planetary laws developed by Kepler in 1609 are not only the basis for modern astronomical calculations, but also the key for engineers designing a planetary gear train.

Johannes Kepler lived during a time of great social and political turmoil. His mother was accused of witchcraft and nearly burned at the stake; his aunt wasn't as fortunate. At the outbreak of the Thirty Years War, Kepler was a young astronomer. Because he was a Lutheran he was exiled from his Austrian home. Fortunately, he was able to get a job assisting the Danish astronomer Tycho Brahe, a man famous throughout Europe for his many notebooks of data on the movements of stars and planets. The scientific world had long awaited the results of Tycho's work and Kepler hoped to get in on a historic development. As it turned out, he did this and more. Tycho died before his data could be evaluated and Kepler became the beneficiary of the Dane's lifework. It took more than 20 years to process and publish Tycho's notes. Although these were valuable, Kepler carried the work further and earned a reputation on his own. While working on these projects, Kepler also cast horoscopes and made astrological predictions for members of Europe's royal courts. This gave him the money necessary to prepare and publish his famed *The New Astronomy*. In this book, Kepler backed the Copernican theory of planetary movement and presented the three planetary laws upon which his fame rests. These laws are generally accepted today.

Ripples, String and Diodes

It is questionable whether Newton was ever struck upon the head with an apple, but it makes a good story. A similar story tells how Michael Faraday got the idea to experiment with oscillatory circuits. It seems that the great electrical pioneer was sitting by a lake casting pebbles into the water. He became curious about the ripples he was making and decided to experiment with water in a vibratory container. His conclusions: there were two complete vibrations of the support for each complete vibration of the liquid.

This theory was debated for several decades, then in 1859, F. Melde experimented with a piece of string and a tuning fork. He found that the string would be maintained in transverse vibration if one of its extremities was

PRODUCT ENGINEERING

ELMER J TANGERMAN *editor*

STANLEY J ALLING *publisher*

ROBERT W CARSON *managing editor*
RICHARD M KOFF *assistant managing editor*

ROBERT E ABBOTT *senior associate editor*

JOHN KOLB *associate editor*
NICHOLAS CHIRONIS *associate editor*
FORD PARK *associate editor*
ROBERT PRENTISS *associate editor*
ANNESTA R GARDNER *associate editor*
WILLIAM GILMAN *associate editor*
FRANKLIN D YEAPLE *associate editor*
JOSEPH J KELLEHER *associate editor*
DOUGLAS C GREENWOOD *associate editor*

BENEDICT A LEERBURGER, JR *assistant editor*
DORA K MERRIS *assistant editor*
HERBERT KEE *assistant editor*
CHARLES J LYNCH *assistant editor*
FREDERICK MARICH *assistant editor*
JOHN PRICE *assistant editor*

FRANCIS E HALL *assistant editor*
BRUCE H FRISCH *assistant editor*
ANITA CAMERIK *assistant editor*

FELIX GIORDANO *Detroit*
SETH PAYNE *Washington*
WILLIAM WALLACE *Los Angeles*

RICHARD E ROOMAN *art director*
E K LOADER *associate art director*
ANGELA M GIACIN *assistant art director*

NORMA J VAN NESS *production supervisor*
LILLIAN M WHITHAM *assistant supervisor*

ROBERT E BRUCKNER *consulting editor*
DOUGLAS GREENWALD *manager, economics services*

C C KANE *reader service manager*

McGraw-Hill News Bureaus

JOHN WILHELM *director*
MARGARET RALSTON *assistant*

GEORGE B BRYANT, JR *Washington*
DONALD MacDONALD *Detroit*
ARTHUR ZIMMERMAN *Cleveland*
STEWART W RAMSEY *Chicago*
JENNESS KEENE *San Francisco*
KEMP ANDERSON *Los Angeles*
RAY BLOOMBERG *Seattle*
B E BARNES *Atlanta*
MARVIN REID *Dallas*
JOHN TUNSTALL *London*
ARTHUR ERIKSON *Paris*
GENE DI RAIMONDO *Milan*
RAYMOND SHAH *Zurich*
CURT AGREN *Stockholm*
ERNEST CONINE *Moscow*
JIM MORRISON *Bonn*
FRED BAER *Vienna*
SOL SANDERS *Tokyo*
JOHN YAMAGUCHI *Tokyo*

A McGRAW-HILL PUBLICATION

November 7, 1960
Vol. 34, No. 46

Executive, Editorial, Circulation and Advertising Offices:
330 West 42nd St., New York 36, N. Y.
Telephone: LOngacre 4-3000
Teletype: TWX NY 1-1636
Cable Address: MCGRAW-HILL, NY

PRODUCT ENGINEERING is published weekly by McGraw-Hill Publishing Company, Inc. James H. McGraw (1860-1948), Founder. US subscription rates for individuals in the field of the publication, $3 per year, single copies 50 cents; Canadian subscriptions $5 per year; foreign $25 per year, payable in advance. Printed in Albany, NY; second-class postage paid at Albany, NY. Title ® registered at US Patent Office. © Copyright 1960 by McGraw-Hill Publishing Company, Inc. All rights reserved, including the right to reproduce the contents of this publication, either in whole or in part.

UNCONDITIONAL GUARANTEE. The publisher, on written request, agrees to refund the part of the subscription price applying to the remaining unfilled portion of the subscription if editorial service is unsatisfactory. PRODUCT ENGINEERING articles are indexed in both the Applied Science and Technology Index and the Engineering Index. PRODUCT ENGINEERING publishes its own semi-annual index. Copies are obtainable on request to the editor.

POSTMASTER Please send form 3579 to Fulfillment Manager, **PRODUCT ENGINEERING**, 330 W. 42nd St., New York 36, NY.

INTERESTING TO NOTE continued

connected to the prong of a large tuning fork. Melde found that the string "settles down into a permanent and vigorous vibration, whose period is *double* that of the fork." Around 1900, scientists began theorizing that electrical vibrations might act in a similar fashion; perhaps they could be amplified by synchronously varying the reactance of a capacitor. This theory proved feasible, but amplifiers could not be made to work at microwave frequencies. By 1955, however, scientists at Bell Telephone Labs conquered this obstacle, developing new diodes, which could handle microwave frequencies. Continued developments have presented scientists with a new vocabulary of electronic terms. The capacitive principle is incorporated in the transducer roundup on page 70.

When Arrows Beat Guns

At the time of the American Revolution there were several good reasons why the colonists might have used bows and arrows as their basic weapons. They still were better, in some respects, than the muskets of the day—as emphasized by Benjamin Franklin in a 1776 letter to Gen Charles Lee, who then was engaged in fortifying the port of New York:

"These were good weapons, not lightly laid aside, because a man may shoot as truly with a bow as with a common musket. He can discharge four arrows in the time of charging and discharging one bullet. His object is not taken from his view by the smoke of his own side. A flight of arrows, seen coming upon them, terrifies and disturbs the enemies' attention to their business. An arrow striking in any part of a man puts him *hors de combat* till it is extracted. Bows and arrows are more easily provided everywhere than muskets and ammunition."

There is a good deal to be said for Franklin's position for, after more than four centuries of development, firearms still were rather primitive. And the Colonies were poorly equipped to produce them. Just when firearms first were used in battle is somewhat debatable. Some stone-throwing mortars were made in Italy around 1312. The first hand firearms were crude iron or copper tubes, fired by applying a live coal to a touchhole. This was a shallow cup at the top of the breech, whence a small hole led downward into the powder chamber. This device usually—but not always—fired the charge.

Most of the trouble with firearms during the succeeding 500 years was due to this ignition system; at least one misfire could be expected in ten shots. The first pistols, known as "bombardelles," appeared in Italy about the middle of the 14th century. The barrels were 9 inches long. In 1544, French cavalry was armed with "pistols" which had obvious disadvantages—their barrels were 25 in. long. One of the newest concepts in firing a pistol is described on page 67—an electrically operated firing pin.

Benedict A. Leerburger Jr

NEXT WEEK IN PRODUCT ENGINEERING

. . . **Trouble? Try Radiant Cooling or Shielding**
For example, let the component run a little hotter—and radiate the heat away.

. . . **For a Stronger Metal Surface**
Practical guide compares hardening and overlaying for boosting wear resistance, bearing and fatigue strength.

. . . **55% Thread Depth Will Make Beryllium Bolts Practical**
New large-radius threads increase fatigue strength; promise better fasteners, beginning with beryllium.

. . . **Designing Pressure Vessels**
Three nomographs aid in finding wall thickness, hoop stress or pressure limit.

. . . **Systems Engineering**
Though it has several roots, it's a specialized new approach to cumbersome problems encountered in large networks of equipment.

LOOK!

14 great new copy machines in the Ozalid®-Ozafax line!

Each one styled, sized, and priced to give you maximum efficiency for every office or plant need.

Got a preference in diazo reproduction equipment? Ozalid dry or Ozafax semi-dry (sometimes known as "moist")—take your choice from 14 brand-new models, rarin' to work for you.

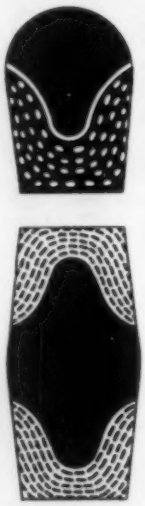
In seconds, these machines make office and engineering reproductions you can hardly tell from originals. Save you time, work, money. Eliminate office copying errors, retyping, proofreading, double-checking. Increase print output, reduce reproduction costs. Paper cost? As little as 1¢ for a letter-sized copy.

Find out about the complete Ozalid-Ozafax line. Talk to an Ozalid salesman or write: Ozalid, Johnson City, N. Y. In Canada, Hughes-Owens Ltd., Montreal.

Ozalid for '61—boldest new look in the business!

DEVELOPMENTS TO WATCH . . .

British design new seals for fluids



Two new fluid seals, one a single-action type and the other a dual unit, provide in effect, a one-piece combination of O-ring and cup to eliminate unnecessary relative motion and wear encountered with conventional packing rings.

The single-action type is basically a U-shape packing, with the "U" filled by a resilient, rounded section which seals but does not tend to collapse under pressure (see diagram). Furthermore, the designers say, the rounded, exposed surface of the "filling" helps to ensure even distribution of fluid pressure. Hall & Hall Ltd, Hampton, Middlesex, England is making it in standard sizes ranging upward from $\frac{3}{16}$ in. ID, $\frac{1}{2}$ in. OD, $\frac{1}{4}$ in. depth.

The dual-acting stype is, in effect a combination of two single units. It is to be made in sizes to fit pistons from 1 to 7 in. dia.

Both units can be supplied in any one of several synthetic rubbers, with cotton or nylon reinforcement. In the diagrams at right, note the rounded resilient filling. Single-action type is at top; newer, dual-action model at bottom.

New treatment boosts carbide's compressive strength

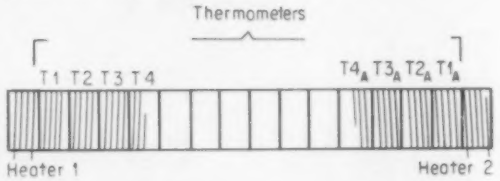
Materials of high compressive strength that "may have immediate practical use" have been produced with relatively simple high-temperature, moderate-pressure equipment, according to a report from Brigham Young University.

By subjecting silicon carbide to 15,000 atmos pressure at 10,000 C, for instance, they've been able to increase its compressive strength 30-fold, says H. T. Hall of Brigham Young.

In addition to the ultrahigh-strength fused silicon carbide, they've made chromium and manganese oxides and zirconium and titanium borides with surprisingly high compressive strengths and several oxides with semiconducting properties.

Present equipment handles quantities of about 10 cc; but the report, prepared by H. Tracy Hall of Brigham Young says the equipment could readily be scaled up to handle at least 250 cc.

Multi-element thermal transducers developed for higher-order transfer functions



For control-system applications involving low frequencies (0.01 to 1 cps) and low impedances (on the order of hundreds rather than thousands of ohms), Australian engineers have devised a simple multi-element design that consists essentially of a metal rod or tube with electrical heater windings at each end, and paired resistance-thermometer windings spaced along its length (see diagram).

The thermometers are so connected that differences of temperature on symmetrically placed zones of the rod can be measured and linearly combined. The output of the device then becomes a function of the sensitivity setting of each pair and the temperature difference between them; while the temperatures themselves are a function of the signal input applied to the heaters.

Sensitivity settings and numbers of thermometer pairs can be varied to achieve the desired output; with the computations involved being simply a matter of solving n linear equations for n unknowns.

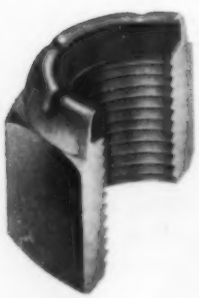
Using this technique, several systems have been designed for temperature and control at the Commonwealth Scientific and Industrial Research Organization, and plans are being made for commercial production.

(Note for another CSIRO transducer, see *PE* Oct 10, p 6).

continued, p 8

When frequent adjustment or dis-assembly is anticipated

USE NYLON INSERT ELASTIC STOP® NUTS



Extended re-useability is built into every standard Elastic Stop nut. The tough nylon locking collar does the trick.

It grips entering bolt threads with a plastic-smooth perfect fit that dampens impact loads, absolutely resists vibration, yet never galls or damages bolt threads. The nut may be "stopped" at any place on the bolt, whether seated or not, for precision adjustment. When the nut is wrenched off for routine maintenance, the nylon collar, due to its elastic recovery, tends to resume its original shape. Thus upon re-installation it grips the bolt threads as effectively as on the original installation. And this on-off cycle can be repeated over 50 times on any bolt of standard quality without loss of holding power.

The nylon locking collar can also be used to seal off liquid seepage along the bolt threads and to prevent moisture from entering the load carrying areas. It is inert to oils, gasolines, salt atmospheres and common acids.

Consider the economy to you and your customers of this kind of fastener performance. Let us prove it to you. Ask for free test samples . . . or a copy of Recommended Test Procedures for Determining Locknut Re-Useability. Write: Elastic Stop Nut Corporation of America, Dept. S50-1145, 2330 Vauxhall Road, Union, N.J.

for the ring of reliability

ELASTIC STOP NUT CORPORATION OF AMERICA

New photocopy machine to meet engineering needs

A dry photocopy machine that will handle all colors of printing—even blueprints—and materials ranging from transparent to opaque, is being developed by Nord Photocopy & Electronics Corp. The company expects to have it on the market within a year. It will be of the electrostatic type, and will make copies in 10 to 15 sec. The machine will be desk size; will handle originals—up to 11 in. wide, and any length. The copies will be permanent, paper will be available in white and several colors.

New polymers show outstanding dielectric properties

A compound with "the most stable dielectric constant over the widest temperature range of any material yet known" was described by three Diamond Ordnance Fuze Laboratories researchers to a recent National Academy of Sciences Conference. The material, a bicyclic nitrile, has a dielectric constant that stays close to 18 all the way from −130 F to "well above room temperature."

Other—and perhaps even better—materials can be expected as the DOFL investigation of this class of compounds continues because, R.W. Tucker of DOFL says, small variations in chemical structure produce marked changes in electrical properties.

Improved aluminizing process claimed by Air Force

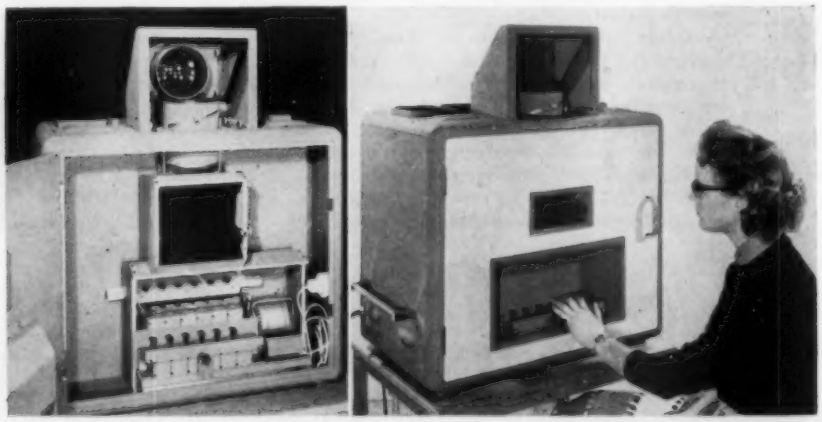
A vapor-deposition technique, said to be first of its type, and particularly adaptable to coating irregularly shaped objects, is reported by Wright Air Development Div, USAF. It uses an organometallic compound (tri-isobutyl aluminum) that decomposes at 500 F, produces an adherent coating directly on low-carbon steel. Says WADD, "The technique will make practical the use of complex steel shapes and fasteners in oxidizing atmospheres at 500 to 1000 F, and lessen the danger of galvanic corrosion."

This machine 'guarantees' random selection

A lottery machine that "shows a truly random distribution of numbers" has been designed by the Central Institute of Industrial Research, Blindern, Norway. It achieves its goal by three security arrangements:

1. All numbers are engraved in random order on the periphery of the wheels.
2. Individual wheels are mounted on a common shaft driven by an electric motor, but are started at different moments by providing for unequal adjustment of the friction couplings.
3. Wheels are stopped individually by operating a brake button that acts on one at a time.

When all the wheels have stopped, a shutter is opened by pulling a handle, and the lucky number can be read. Then the release knob starts the process over again. Operation takes only 2 sec (plus reading time); and the machine can be arranged to project the numbers on a screen or to operate by remote control. Photos show the machine open and in use. —ARG



WHAT'S HAPPENING IN RESEARCH . . .

Hydraulic-actuator study highlights unsolved problems

In a design study sponsored by the Air Force and the AEC, engineers of GE's Military Electronics Dept have been trying to find out whether existing hydraulic-control actuators could be adapted for high-temperature aircraft and nuclear reactor systems. In several respects, the answer so far is "no."

"Considerable effort," GE engineers say, "has been expended on development of high-temperature piston rod seals." But "the results of the search have been negative."

Because most elastomers and plastics would be degraded either by the high-temperature (500 to 600 F) fluid or by nuclear radiation, or both, the search concentrated on metal-foil seals and fibrous materials. But no satisfactory system has been found.

On accumulators, the tests were a little more encouraging. Conventional types won't do, but it may be possible to develop gas-loaded metallic bellows that will serve satisfactorily.

For other components—pumps, gas separators, and heat exchangers—the outlook is considerably better. A constant-displacement ball pump has been designed for service under the specified conditions and a centrifugal gas separator is under consideration.

A copy of the report, detailing design problems and illustrating the various types of components tested, may be obtained from Office of Technical Services, Dept of Commerce, Washington 25, DC. (APEX-556, 92 pages, $2.25). For additional information on the high-temperature fluids for which units of this type are being designed, see *PE*—Oct 24, p 39.

Fluorine plastic lubricates vacuum system

Solid TFE resin is the bearing lubricant in one new high-vacuum system designed at California Institute of Technology.

The reason: the unit is part of an X-ray spectrometer, and had to operate at high temperature as well as low pressure. Hydrocarbon lubricants and oil mists could not be used because of the danger of contamination. Barium was ruled out by the presence of air. Graphite was too abrasive; and molybdenum disulfide simply did not provide sufficient lubrication. But, R. H. Willens of Cal Tech reports in *Review of Scientific Instruments*, TFE (Teflon) fluorocarbon did the trick, and just by the simple means of rubbing the bearings against a solid piece of the plastic.

For ballbearings, this was done by replacing the steel cage with one of Teflon. In sleeve bearings, the answer was Teflon inserts. For thrust bearings, several designs were used. The fluorocarbon plastic seems particularly desirable, Willens says, because it has excellent stability under vacuum conditions and low vapor presure.

Briefing the Soviet record

To cool turbine rotors, blow the air *through* the blade roots, say I. T. Shvets and Y. P. Dyban of the Ukranian Academy of Sciences. It's much more effective than forced radial air blowing. They've been testing gas turbine rotors operating at or below 1000 F (inlet gas temperature 1300 to 1470 F), and claim to have developed a calculating method for such systems "sufficiently exact to be recommended for use in designing air-cooled drum- and disk-type rotors."

The report was published in the Soviet magazine *Mashinostroyeniye*, No. 2, 1960.

To increase strength of austenitic steels, Soviet metallurgists are recommending phosphorus additions. Alloying with phosphorus (in fractional percentages) markedly improves the yield and stress-rupture characteristics of stainless, both at room temperature and in the 1200 to 1400-F range. Furthermore, they say, addition of 0.3% phosphorus to nickel-bearing (7 to 9%) steels also improves heat resistance. A report appeared in *Chermaya metallurgiya*, No. 6, 1960.

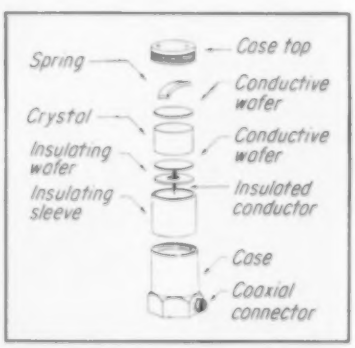
Sintered copper alloys, dispersion-hardened by alumina, are under test at the All-Union (USSR) Scientific Research Institute of Hard Alloys. Addition of 1 to 3% alumina to copper powder increases tensile strength 50% and hardness 100% or more, and shifts the recrystallization temperature from 570-F to the 1100 to 1300-F range, a report in *Tsvetnyye metally* No. 7, 1960 claims. —ARG

Transducers in the lab

Applications for piezoelectric crystals in laboratory work are outlined by New York Testing Labs.

Pointing out that a piezoelectric crystal is essentially a capacitor, NYTL notes that the voltage of the induced electrostatic charge can readily be monitored by appropriate instrumentation (vacuum-tube voltmeter, cathode-ray tube, or oscillograph). In this way, the characteristics of the applied force, which generates the charge, can be determined.

Applications range from shock and vibration studies to hydraulics tests. Advantages of such systems, says NYTL, include rapid response to change in force, nearly constant ratio of generated voltage to stress over the application range, freedom from hysteresis effects, stability over a wide temperature range (depending on the specific crystal used.)

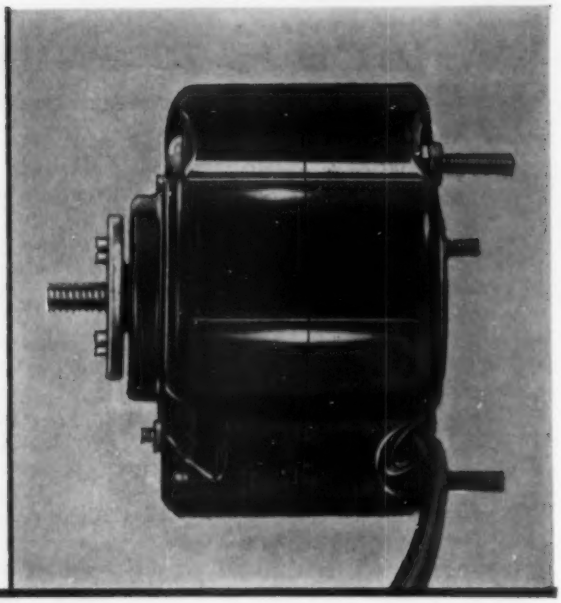


PIEZOELECTRIC TRANSDUCER diagramed here is typical. Upper leg of electrical circuit includes crystal face, upper conductive wafer, spring, case. Lower leg starts with lower crystal face, includes parts beneath it.

A 4-page leaflet, providing information on piezoelectric crystals, and telling how to use them in engineering research is available from NYTL.

NEW DUAL-BEARING UNIVERSAL MOTOR

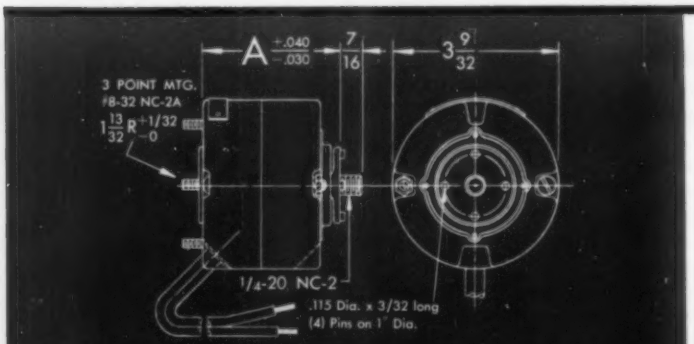
provides dependability and long life in Refrigeration Fan Applications



The Type 118H-3, shaded-pole hubless fan-motor is a rugged, new, precision built motor that has been specially designed to precisely meet the needs of refrigeration manufacturers. The 115 volt-60 cycle-1550 RPM model is totally enclosed and suitable for all angle operation. It conforms to all existing dimensions and has the standard 3-stud mounting and the 4-pin hubless adapter so that it can be installed as original equipment without modification.

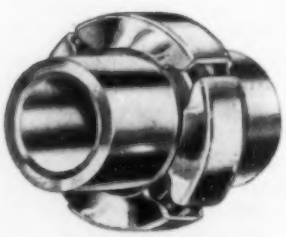
This new Type 118H-3 has two *free-aligning* **Universal Bearings** located at either end of the shaft rather than a conventional single bearing. These bearings are of an advanced design and eliminate fractional HP motor problems due to misalignment. Each has its axis of support at the center, rather than at the end; they are therefore always in balance and adjust themselves to shaft misalignment under any load conditions. This results in longer bearing life and assures a motor that is efficient, sure starting and quieter. These bearings are self-lubricating and each one incorporates an extra large, life-time oil reservoir.

Due to the two *free-aligning* **Universal Bearings**, the newly designed laminations and the improved rotor construction, the Type 118H-3 Universal Motor will provide years of reliable, trouble-free operation. Special windings are available on request; write for complete information.



115 Volt—60 Cycle—1550 RPM
"Universal Bearing"
All Angle Operation
High Impedance Protected
Totally Enclosed
No Oiling Required
Special Windings on Request
Rotation Determined Viewing Shaft End

Watts Output	Amps.	A
4	.42	2.442
6	.45	2.817
9	.50	2.817
12	.60	3.317



New Universal Bearing has support pressure on center of bearing rather than the end to eliminate uneven tension and permit adjustment of axis position to *true* alignment. Neoprene collar around outside surface of bearing accommodates manufacturing tolerances; small metal clips confine collar, allow free sliding movement along bearing support surface.

UNIVERSAL ELECTRIC COMPANY

PRECISION ELECTRIC MOTORS

EXECUTIVE AND GENERAL SALES OFFICES: OWOSSO, MICHIGAN, DEPT. 12

54

Easy to install! Easy to service! Hard to wear out!

LINK-BELT "RC" COUPLINGS

Here's a flexible coupling that's ✓simple ✓dependable ✓inexpensive

SIMPLE! Link-Belt "RC" couplings consist of two sprocket halves joined flexibly with a piece of roller chain. The chain is specially constructed for flexible coupling service—it is of single width construction, but has extra overall width and *divided rollers* which provide independent contact with each sprocket tooth . . . equalize load . . . compensate for shaft misalignment. Especially important, "RC" couplings are easy to install . . . easy to take apart and put together.

DEPENDABLE! Chain and sprocket halves are made of quality steel. In addition, sprocket teeth and chain parts are hardened. The resulting *extra* strength and wearability pays off in long, dependable service.

INEXPENSIVE! Extremely simple design holds down the cost of "RC" couplings.

HARDENED WEARING SURFACES of both chain and sprocket add extra wear-life to "RC" couplings.

CHOICE OF HOUSINGS

— for retention of lubricant and protection of the coupling. Style R — spun metal, vertical split. Style P — molded plastic, horizontal split.

FULL DETAILS are contained in Book 2363. For your copy, call your nearest Link-Belt office, listed under COUPLINGS in the yellow pages of your phone book.

LINK-BELT

"RC" FLEXIBLE COUPLINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.

FROM WASHINGTON . . .

Navy radiotelescope 2 years behind schedule

The Navy is having design problems in building its 600-ft-dia radiotelescope at Sugar Grove, W Va. Completion date for the project has already been pushed back from 1962 to 1964 (and costs have risen from the original estimate of $79 million to over $100 million).

An IBM 704 computer has been working for months on stress-analysis details so that detail designs can be made. The problem, however, is not simple. When completed, the huge 28,000-ton steel-and-aluminum structure must be accurate to a tolerance of 1/4000 in. It must rotate in azimuth 360° and over 90° in elevation. And change of direction must be done without any backlash.

In addition, the aluminum mesh-lined, saucer-shape antenna, covering 7.4 acres in size, has to be sturdy enough to withstand wind velocities of 90 mph and operate in velocities of 50 to 55 mph.

Dual 10-in. rail tracks with monorail power units will maneuver the radiotelescope in azimuth, and four friction power drives will control the elevation. The Electric Boat Div of General Dynamics Corp is developing these units for the Navy.

A 116-ton pintle bearing will prevent lateral movement of the telescope. General Steel Casting made the casting, with Baldwin-Lima-Hamilton doing the milling.

Navy will use the Sugar Grove radiotelescope for top-secret communications work. And, on a time-allowable basis, scientists will use the facility to search out radio signals coming from stars.

Samos a specialized spy satellite

Unofficial reports claim that the Air Force's Samos spy satellite will photograph enemy installations with the same detail as that seen by a person standing 100 ft away from the object. However, the service won't comment on the matter officially.

One or two additional Samos launchings are planned this year. The first failed to orbit when launched Oct. 11. From 10 to 12 launchings in the Air Force's Discoverer, Midas, and Samos series are slated both in 1961 and 1962.

By late 1963, the Samos and Midas military intelligence-gathering satellite systems are due to be in regular use. Earlier test versions will be feeding back limited information also. Samos will photograph enemy installations; Midas will detect missile firings through its infrared sensor system, then flash a warning to ground monitoring stations.

Navy plans deep-sea locker for its oil supplies

Underwater petroleum-storage tanks are being tested by the Navy. Long-range plans call for a series of such ocean-bottom storage areas, each with capacity of over 1 million gal.

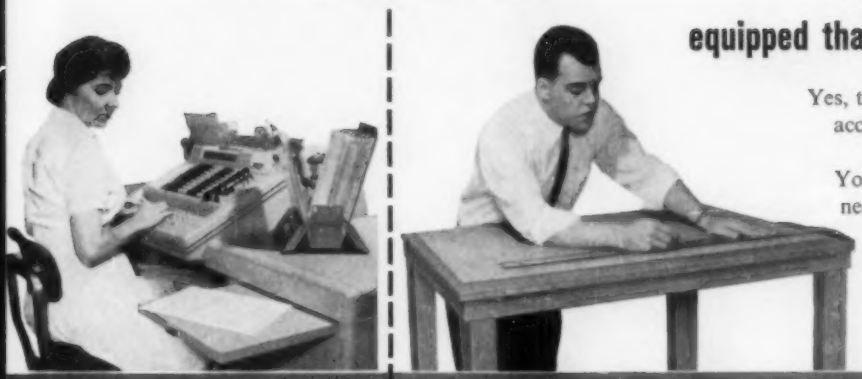
Right now, Navy has a 50,000-gal. rubber tank under test off the Louisiana coast. Submerged in 52 ft of water, the 20-ft-wide, 68-ft-deep tank is held to the ocean floor by a tubular-steel frame and nylon harness.

Fittings let ships or submarines receive from or discharge to the tanks. Built by US Rubber Co, flexible hose links the storage tanks to an underwater steel header tank, then to a surface buoy. Gages on the surface buoy indicate the amount of oil in the submerged tanks.

Potential nuclear-blast damage and high cost of land-storage areas are the reason Navy is turning to underseas stockpiles. Eventually, some officials predict, underwater storage farms will be located at strategic points around the world. Right now, storage of such commodities as fuel oil, gasoline, lubricating oils, and fresh water are envisioned. Long range, however, even solid materials may end up in deep-water storage, some Navy officials predict.

CIRCLE 13 ON READER SERVICE CARD→

(What's wrong with this picture?)



Are your bookkeepers better equipped than your engineer-draftsmen?

Yes, today's bookkeeping procedures demand accuracy and productivity—equipment that guards against error, while saving time. Your professional engineer-draftsmen, too, need modern equipment for top efficiency, as their work helps establish your productivity throughout the *entire* product-planning and manufacturing cycle.

Your draftsmen, your productivity, deserve new Hamilton space-and-time-saving equipment—from Bruning

You *keep* your best men productive by giving them the equipment they need to do their best work, and you eliminate costly errors fostered by inadequate or antiquated equipment. In Hamilton equipment, *you get top productivity for every square foot of floor space.*

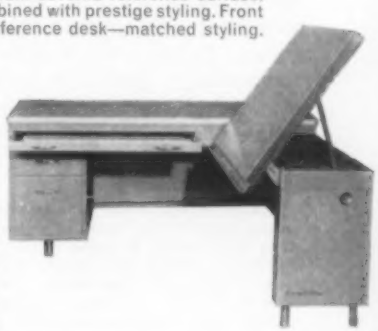
Not only do all Hamilton units start to pay you the minute they go on the job, but they *keep* working harder for you *every* minute—because they're so ruggedly constructed, designed for greater ease and comfort—consequently lower fatigue.

The Hamilton units are themselves a product of meticulous engineering and long experience—features and dimensions established as *ideal*, in many thousands of industrial installations. Yet they deliver the flexibility that every individual and every department require. Our experienced planning engineers are at your service to help select the best arrangements for your needs.

Hamilton De Luxe Auto-Shift Tables
Scientifically seasoned drawing surface; concealed mechanism controlling height and slope flexibility, can be moved with fingertip pressure; linoleum-covered reference surface. Many functional features, combined with prestige styling. Front table, basic table, and rear reference desk—matched styling.

Hamilton CL 100 Series
Entirely new, canted-leg styling assures stability without side crossrails. Strata-Core board, with green linoleum surface, both sides steel edged; tilts 0° to 40°. Fully adjustable recessed footrest; steel reference, tool, and catalog drawers. Other fine features, superb styling in light Sahara-Tan, satin-chrome hardware.

Hamilton L-Contour Unit
Counterbalanced, range of board adjustments permits frequent position changes—at finger touch—offering greater flexibility of work arrangement, lessening fatigue. Telescoping legs adjust height 30" to 31". Generous storage facilities, durable linoleum reference surface. Beautiful utilitarian styling, maximum space efficiency, constructed for long service.



Put draftsmen in a "position" to do better, faster work!

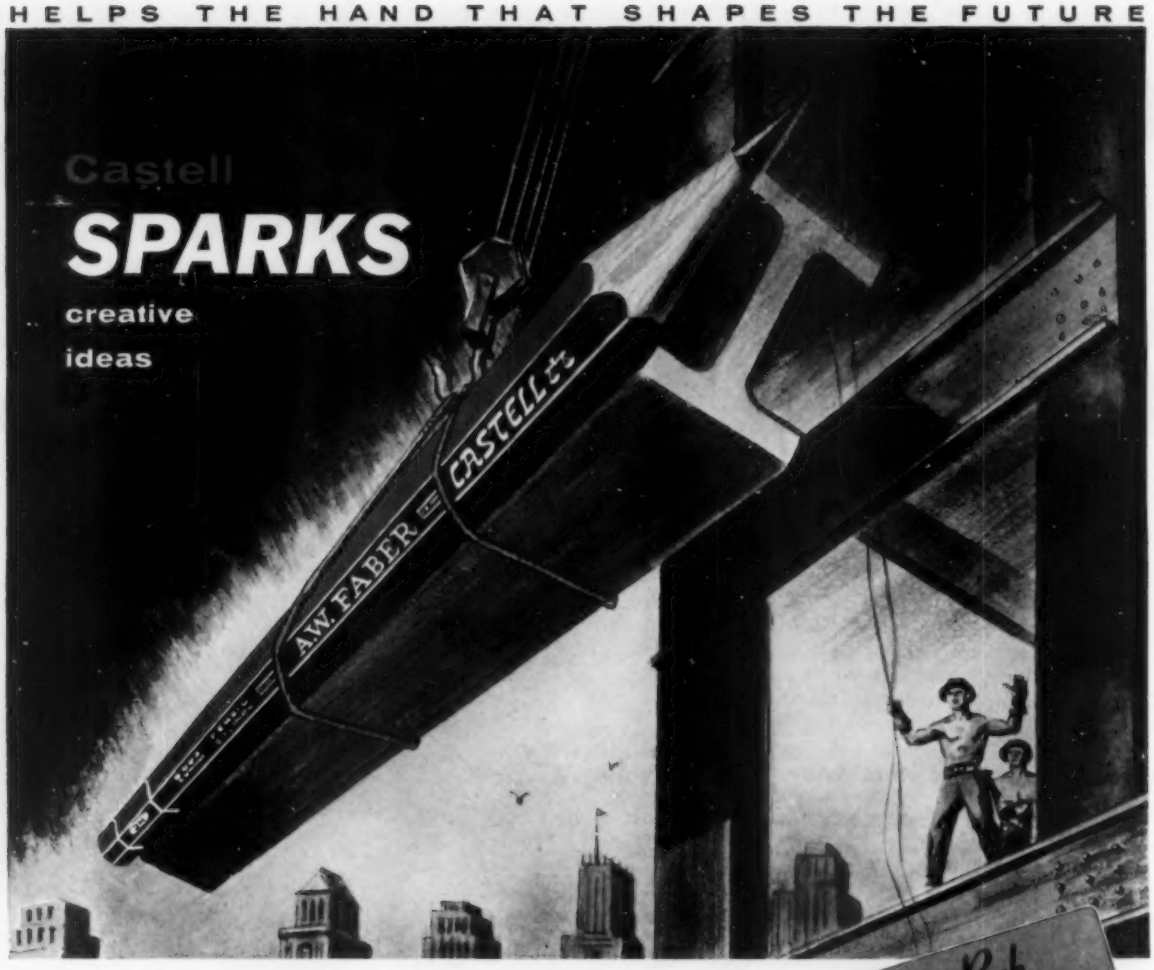
Bruning's all-new Neoglide drafters literally help draftsmen straighten up and do faster, better work.* They provide complete maneuverability on any board at any angle without adjustment! Reinforced U-beam construction assures rigidity, strength, and accuracy. Resistance-free movement of vertical beam and hidden counterweight provide fast "floating" action. Touch-control protractor head gives automatic, pinpoint angle selection.

*Study of 300 draftsmen showed 35% savings in drawing time—1/5 the backaches—on vertical or near vertical boards.

BRUNING

CHARLES BRUNING CO., INC.
1800 CENTRAL RD., MT. PROSPECT, ILLINOIS

HELPS THE HAND THAT SHAPES THE FUTURE



The creative man's brain is awhirl. Instinctively his hand reaches for his CASTELL pencil. The brain child is locked within. Now it must be brought to life on a plane surface to conform to the nebulous image. CASTELL, the world's finest drawing pencil, is the trusted intermediary. Because it is itself conceived and produced with the care and skill of a precision instrument, CASTELL is the partner of progress the world over. To a creative man, CASTELL is an unquestioned fact of life.

#9000 CASTELL Pencil with world's finest natural graphite that tests out at more than 99% pure carbon. Exclusive microlette mills process this superb graphite into a drawing lead that lays down graphite-saturated non-feathering lines of intense opacity for cleaner, more durable originals and clearer, sharper prints. Extra strong lead takes needlepoint sharpness without breaking or splintering. Smooth, 100% grit-free consistently uniform pencil after pencil, in full range, 8B to 10H.

#9007 CASTELL Pencil with Eraser.

CASTELL Pencils and Leads draw perfectly on all surfaces, including Cronar and Mylar base films. Give graphite-saturated lines, easy to erase, no ghosting — excellent reproduction.

***CASTELL** Rubberless MAGIC-RUB ERASER soaks up graphite without abrading drawing surfaces, and residue rolls off. Leaves no "oil" stain or "ghost." Tests highest in ease of use, line removal and non-smudging. Tests first on Cronar and Mylar base films. For all papers and vellums.*

#9800SG CASTELL LOCKTITE TEL-A-GRADE Holder, perfectly balanced, lightweight, with new no-slip functional grip that lightens finger pressure without slipping, and *relieves finger fatigue.* Unique degree lead indicating device.

#9030 CASTELL Refill Lead, matching exactly #9000 pencil in quality and grading, degrees 7B to 10H, packed in reusable plastic tube with gold cap.
Many other styles and colors of CASTELL Pencils Holders and Refill Leads.

A.W.FABER-CASTELL 41-47 Dickerson Street, Newark 3, N. J.

THE ENGINEERING WEEK

Space Industry Lists Future Product Needs

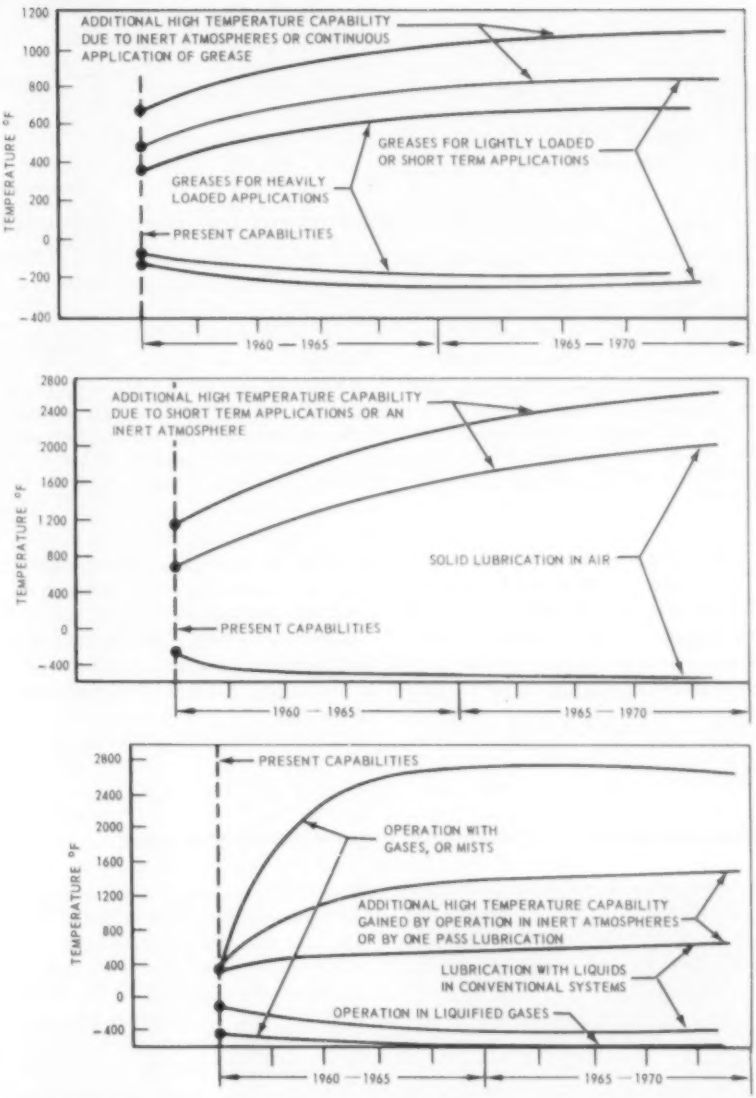
WASHINGTON—A forecast by the Aerospace Industries Association (AIA) lists scientific and engineering advances needed in the next decade if the US is to capture and hold the lead in the international race for aeronautics and astronautics supremacy. Among the needs listed were:

Sheet-forming equipment to produce parts closer to final configuration. High-yield alloys (350,000 psi) during the next five years will be available only in sheet and bar form. The forming equipment is needed to minimize rising costs. Besides high-energy forming, and precision and spin forming, advances are needed in extruding, casting and deep-drawing.

Cutting equipment must be developed for the newer materials. Operations such as shearing, blanking and machining, now performed at room temperatures, will have to be done with tools and materials at very high or sub-zero temperatures. Chemical milling must be further developed for use as a "finish" process to remove all excess weight from structures fabricated from high-strength materials.

Numerical tape control will have to continue reaching into the areas of lofting, drafting, testing, inspection and system checkout. As more-efficient computer programs and data-processing techniques are developed, pre-programed data will be applied into an integrated system of manufacturing, from design concept through the final checkout of weapons system.

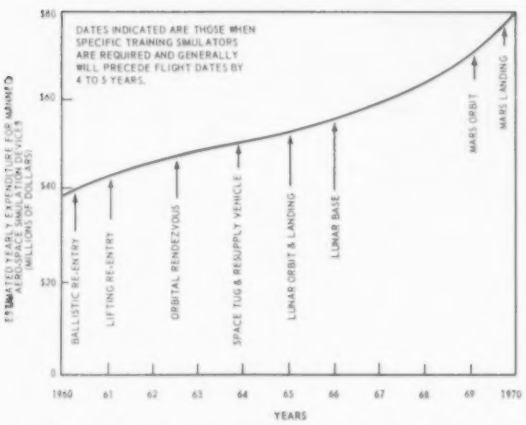
Methods of joining materials must be upgraded as greater joint-strength requirements are demanded. Assembly of components into lightweight, fuel-tight structures will place emphasis on fusion rather than resistance-welding processes. Improved ultrasonic welding might be adopted, with the welding medium being powdered or granular, and attracted to the weld joint magnetically to allow welding at low temperature. A method of joining metals without heat is needed, and welding of fibrous materials used for transpiration cooling requires investigation. Techniques are also sought for welding refractory metals to dissimilar metals, and metals to glass.



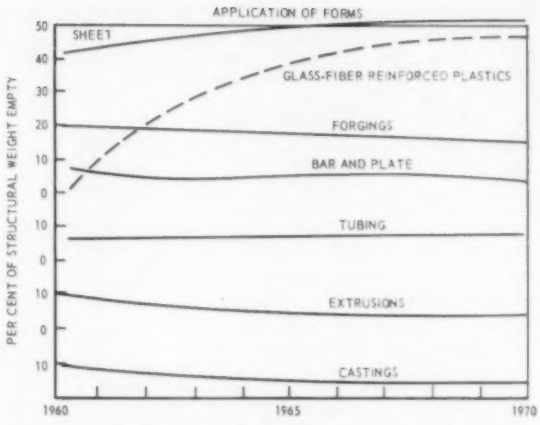
LUBRICANT IMPROVEMENTS are a must for the aerospace growth forecast. Progress in the field of solid lubricants depends on progress in the field of high-temperature alloys. Non-oxidizing base metals, with high strengths and hardness at elevated temperatures, are a necessity.

Techniques and equipment must be developed for special handling and storing of many materials. Wide, extremely thin sheet material must be transported without deformation. Exhaust and filtering systems will be widely needed to reduce health hazards in processing toxic materials. Any use of radioactive products will require special automatic or remote-control machines, controls for chips and coolants, insulating materials, measuring methods or gages, and waste-disposal equipment and techniques.

Training, particularly for space



SIMULATION FACILITIES, both for research and training, will increase as manned aerospace vehicles are planned and built. Many of these facilities will be at "holding bases" to maintain crew efficiency between launches and recoveries. Some will be on space stations and other planets.



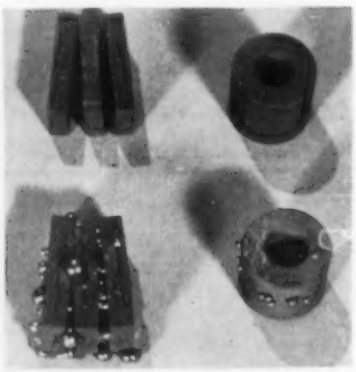
SHEET MATERIALS will be used more, and cast and wrought forms less, as missile and spacecraft airframes replace conventional aircraft. Glass-fiber-reinforced plastics will grow rapidly because of intensive development and research being applied to its use in motor cases and nozzles for solid-fuel missiles.

flights, must increase. Estimates say that a two or threefold increase in human-factors personnel will be needed by 1970 to cope with problems of human existence and performance under increasingly severe environments, and in more-complex systems. High-fidelity flight simulation must expand to study man's performance under combined stresses of noise, vibration, acceleration, temperature, isolation, and others. The present $40 million for aerospace simulation devices is expected to double in the next 10 years.

Other predictions are made in the fields of communications, electronics, space flight, and aircraft speeds.

The forecasts were prepared by technical committees of the AIA. Essentially long-term, they were made in the light of contemporary knowledge and currently anticipated aerospace systems. ■

Metal-bonded Graphite—New Bearing Materials



LIQUID-PHASE SINTERING additions make possible bearing materials for both dry and externally lubricated bearings. Compositions prepared at Ford Scientific Laboratory range from 40 to 90% graphite by volume. At top are forms of the new material; by contrast below are typical materials showing usual incompatibility of graphite and liquid metals. Samples of the material for test are available from Dixon-Sintaloy Inc.

PHILADELPHIA — Recently developed metal-bonded graphite materials that combine the strength of metals with the unique antifriction properties of graphite were discussed at the AIME meeting here. Dr Michael Humenik Jr, of the applied science department of Ford Motor Company's Scientific Laboratory, said potential applications of the new materials lie in the field of both dry and externally lubricated bearings.

GRAPHITE SHOWS STRENGTH

He explained that those of the new materials rich in graphite would be suitable for dry bearing applications. They have shown higher strengths than the best offered by pure graphite materials, also give improved mechanical properties and close dimensional control of parts, and can be made by high-volume powder-metallurgy production techniques. The metal-rich compositions, Dr Humenik said, compare favorably with strongest materials obtained in porous compositions used for externally lubricated bearing applications, and have much higher range of satisfactory performance. The new materials also are being considered for possible use in electrical and specialized high-temperature applications.

The production process, Dr Humenik said, follows conventional powder-metallurgy techniques but with one difference—addition of a powdered calcium-silicon alloy during the liquid-phase sintering. Without this addition the resulting product is weak and extremely brittle because of the poor compatibility between liquid metals and graphite. Besides the liquid-phase sintering of iron-graphite compositions, nickel-, cobalt-, copper-, silver-, and aluminum-graphite combinations have been successful.

—Felix Giordano, Detroit

World's New Length Rule Based on Krypton 86

PARIS—The world has a more accurate international standard of length, now that the 11th General Conference of Weights and Measures has unanimously agreed to redefine the meter as 1,650,763.73 wavelengths of orange-red light emitted by the isotope krypton 86.

Adoption of the new standard, which replaces a platinum-iridium bar kept since 1889 in a vault outside Paris, makes it possible to check measurements to an accuracy of one ten-millionth of an inch or better, ten times as accurate as the bar.

The conference also adopted an interim standard for the second, establishing the basic unit as the length of a second on Jan 1, 1900 at zero hours. This will eventually be replaced by a time unit based on oscillation of a cesium atom. A time unit based on the earth's revolution, which varies, is no longer adequate for the space age, scientists at the conference agreed.

MILLIONTH AS GOOD AS MISS

Long-range implications of the new length standard are tremendous, according to Louis Polk, president of The Sheffield Corp, subsidiary of Bendix Aviation Corp, and one of the US delegates to the conference. In a moon-shot, for example, Polk pointed out, misalignment of a millionth of an inch would cause a miss —but the krypton 86 measure would allow a millionth of an inch to be split.

Polk added that the new standard makes it possible for anyone who needs split millionths to have a standard in his own laboratory; and such close-tolerance measurements can be repeated anywhere in the world. Measurements on a 4-in. block recently circulated among Great Britain, Germany and the US were identical to a ten-millionth, using a krypton source, he said.

Polk hailed the new standard as a breakthrough and predicted that, in five or six years, accuracies of one part in a billion will be achieved.

—Art Erikson, Paris Bureau

Engineering Loses Students to Other Sciences

CHICAGO—Engineering schools are suffering a decline in enrollment because qualified students are becoming more interested in other fields of science. That's one of the opinions expressed by a group of engineering-school deans polled by Dr John T Rettailiata, president of Illinois Institute of Technology.

Other factors mentioned by the educators include concern over the rigorous demands of engineering curriculum, and a decline of genuine motivation for engineering.

The deans also pointed out that many students are receiving inadequate highschool preparation. They accused the profession itself of failing to make the student aware of career opportunities and warned that uncommitted students should know fully what engineering can offer them.

Rettaliata warned that "unless" there is a change in enrollment trends, our tradition of national accomplishment will be in jeopardy."

He noted that civilized peoples are becoming ever more dependent upon research advances stemming from discoveries made in our present scientific revolution. Impetus for continued growth can come about only through greater support for science.

The ITT president stressed that there will be an explosive advance along every expanded frontier in science and technology. He added that "colleges and universities must leave their ivory towers to satisfy a continuing requirement to keep education up to date by constant evaluation of our curricula to meet the need of the times."—Bruce Cross, Chicago Bureau

EPA to Distribute Soviet Translations

PARIS—A European center to collect and distribute translations from Soviet-bloc publications has been set up in Holland at the Univ of Delft's Technical Library.

Sponsored by the European Pro-

Continued on page 20

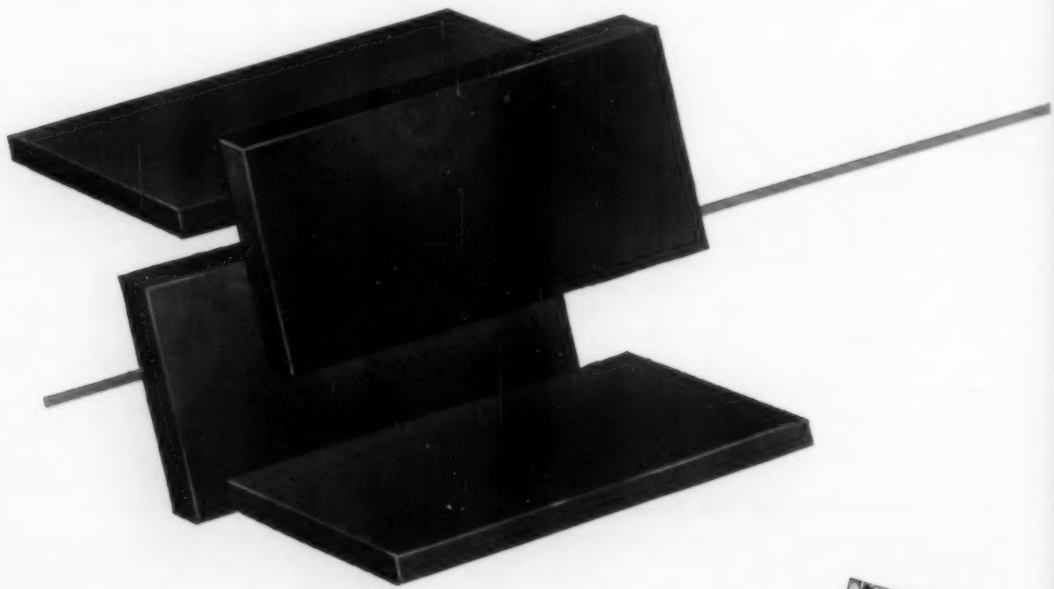
Land Tanker Redesigned From Stem to Stern

The most impressive vehicle at the British Motor Show in London is the BP Trader-John Thompson-Leyland "Autotanker." It's a multi-compartmented, 4000-gal. tanker, with the cab and front-wheel assembly welded to the forward frame, and a packaged transverse engine-transmission combination on a rear-detachable subframe. It has power steering, combination air-leaf spring suspension, and a powered hand brake. Crew access is below the windshield through a single front panel, and the driving compartment has adjustable aircraft seats, electroluminescent panel lighting, and a wraparound windshield. Integral light-alloy construction gives a 16-ton payload (weight empty, 8 tons) and the rear-mounted engine reduces clearance height by 2 ft because of absence of a driveshaft. A fully engineered optical system gives driver a rear view that almost includes the tail lights. The BP "Autotanker" is powered by a 200-hp diesel engine manufactured by Leyland of England.

GRAPHITAR® VANES
(CARBON-GRAPHITE)

and long life of CONDE

This rotary positive displacement pump, engineered and produced by the Dri-Air Pump Department of the Conde Milking Machine Company, Inc., of Sherrill, N. Y., is designed to deliver clean, dry air or gas for high vacuum and low pressure applications in hospitals, dental offices, chemical or pharmaceutical plants, industrial processing systems and in metalworking plants. Thanks to vanes of GRAPHITAR, the CONDE Dri-Air Pump gives years of trouble-free, continuous operation at maximum recommended vacuum and speed . . . *without lubrication!* The GRAPHITAR pump vanes are self-lubricating and are seated by centrifugal force. Operating with a minimum of friction, they become increasingly efficient as the pump is used. In addition to their self-lubricating properties, the GRAPHITAR vanes are hard, light, non-sticking, non-warping and chemically inert. Perhaps these qualities can be utilized to advantage in your products.



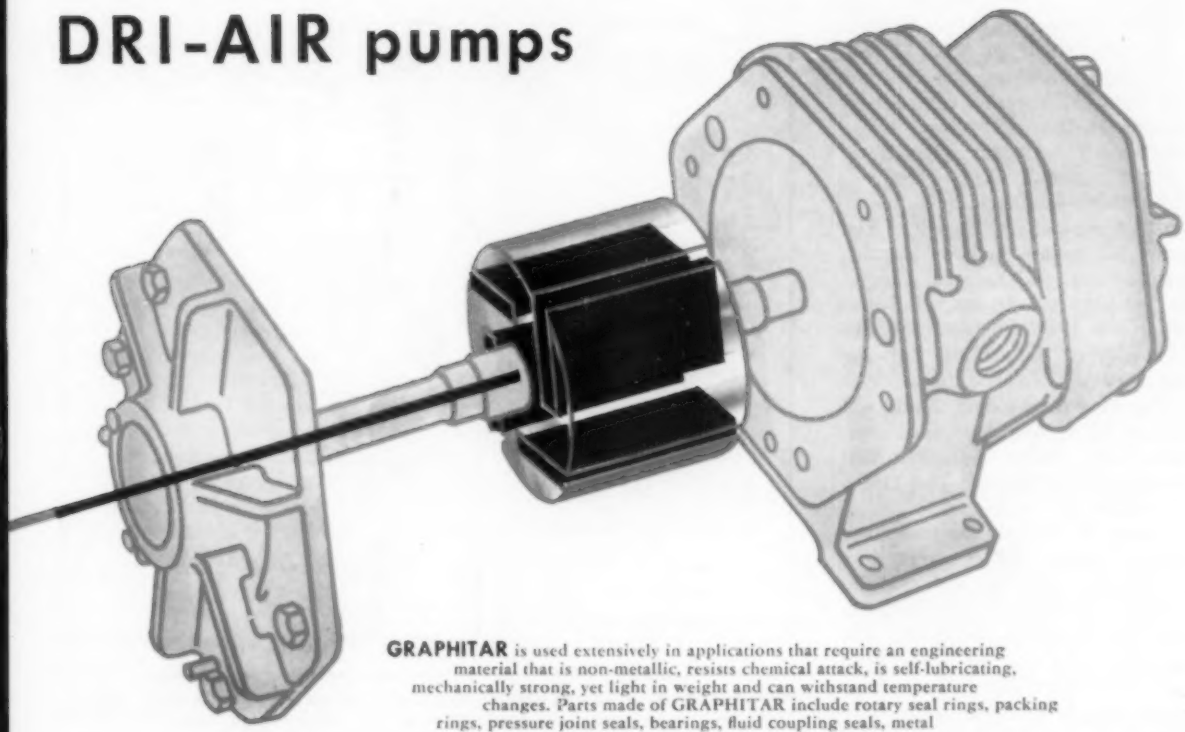
Bulletin #20 includes detailed design data along with properties, characteristics and typical applications of GRAPHITAR. Write for your free copy. If you have questions concerning the incorporation of GRAPHITAR parts in your products, our engineers will be glad to assist you.

THE UNITED STATES

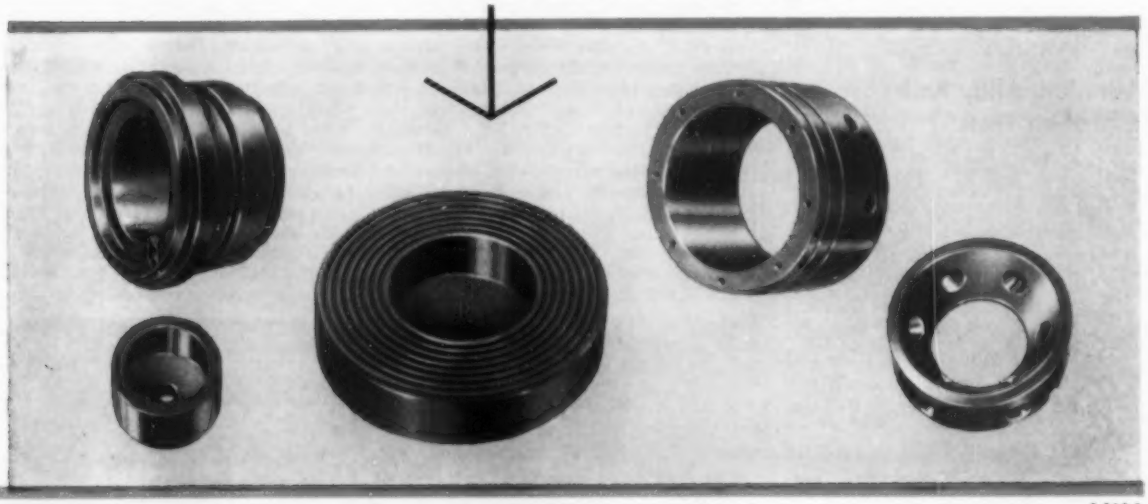
GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

help insure efficiency

DRI-AIR pumps



GRAPHITAR is used extensively in applications that require an engineering material that is non-metallic, resists chemical attack, is self-lubricating, mechanically strong, yet light in weight and can withstand temperature changes. Parts made of GRAPHITAR include rotary seal rings, packing rings, pressure joint seals, bearings, fluid coupling seals, metal backed bearings, piston rings and pump liners.



R-285-2

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 1, MICHIGAN

continued from page 17

ductivity Agency (EPA), the center got the green light in mid-October from representatives of 12 European countries, the US and Canada (*PE—Feb 29 '60, p 17*). It will start with a stock of about 40,000 translations.

The center will get copies of non-commercial translations of scientific and technical literature collected by national centers in the participating countries. The US, for example, will contribute about 18,000 abstracts, 3500 photocopies and 8000 microfilms of translations annually. The center wil publish bulletins showing new additions and keep an index of all available translations. Bulletins will index commercially available cover-to-cover translations, but the center will not circulate them.

Operating costs for the center will be met by levying a nominal overhead charge, along with reproduction charges for translations. The Dutch will absorb any operating deficit.

During its first year, the center will operate under EPA sponsorship; membership will be restricted to member countries of the Organization for European Economic Cooperation, EPA's parent body. After that, EPA hopes the center can go on its own. It may then open membership to non-OEEC countries and enter nontechnical areas. ■

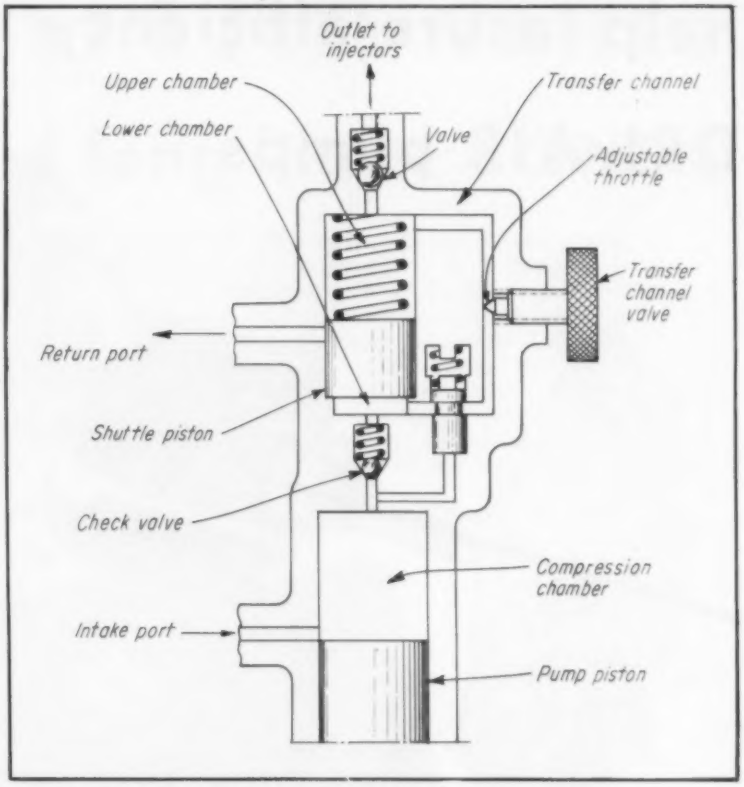
Titanium Alloy Fails Extrusion Tests

NEW YORK—One titanium alloy has just about "had it." This is Ti–1.5 V–15 Al. After an extensive series of extrusion tests, Naval Research Lab is convinced that this alloy is inherently brittle. Furthermore, even under the best conditions, it does not show the expected tensile strength.

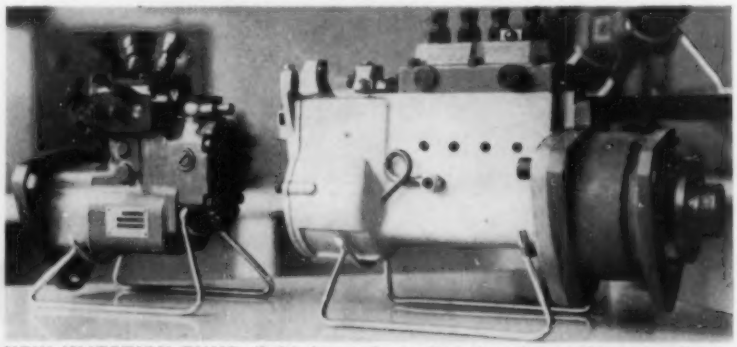
Ingots clad with stainless steel and heated to 1900 deg Kelvin could not be extruded at all, even with a 650-ton press.

With a mild-steel case, and an extrusion temperature of 2100 F, success was achieved at a breakthrough load of 620 tons, and the billet was in fairly good condition. But tensile tests on the resulting material showed only 74,000 psi—well below the expected 100,000 level. Concludes NRL: Further work along these lines is probably not justified. ■

New Pump Is Focus of Paris Auto Show . . .



PRINCIPLE OF OPERATION of diesel-injection pump. At start of cycle, a fuel pump incorporated in the unit fills the compression chamber. Oil is compressed as pump piston starts upward stroke. Under pressure, transfer-channel valve closes and checkvalve then opens because its spring is stiffer than the transfer-channel valve's. Pump piston continues upward, forcing oil into lower part of chamber in which shuttle piston rides. This forces shuttle piston off its seat, sending oil in upper part of chamber through checkvalve to injector. Cutoff of injection occurs when shuttle piston clears return orifice. Note start of injection cycle depends on pump piston, which is driven by a camshaft linked to engine camshaft. As pump piston starts downstroke, transfer-channel valve opens and spring-loaded shuttle piston moves down, forcing oil from lower chamber into upper chamber through transfer canal. If canal orifice is wide open, shuttle piston bottoms on its seat. But if orifice is restricted, shuttle piston's descent is slowed. Thus pump piston will be on its way up before the shuttle piston reaches its seat; flow through checkvalve will stop the shuttle piston and start it back on a shorter stroke.



NEW INJECTION PUMP (left) is much smaller than its predecessor. Prototypes are being road tested on diesel-engine Peugeot's.

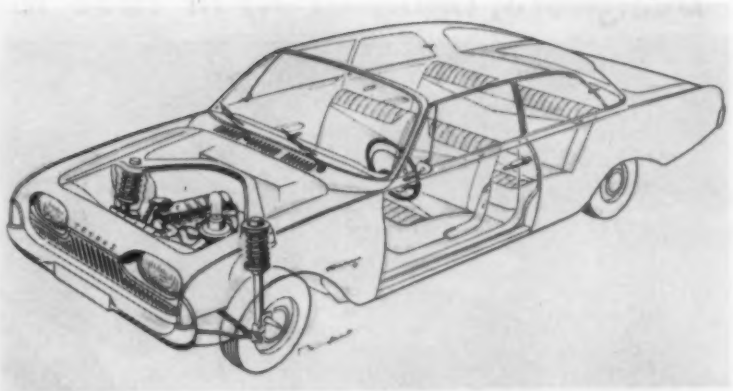
. . . But Styling Prevails

PARIS—The annual auto show here was this year typically Parisian—more style than technology. However, a real engineering advance was a diesel injection pump (sketch at left). Its "liquid stop" automatically regulates output to suit load-speed changes. Ford of Germany (photo at right) and Bernard of France were standouts among the stylists.

The pump, built by Precision Mecanique Labinal and intended for passenger-car engines, employs a single rotating piston to supply all four cylinders. Though not an innovation, this facet of the design does account largely for the small size and light weight of the unit.

The design departure lies in the "liquid stop." It provides the self-regulating action which for many motors eliminates need for an automatic advance. It allows injection timing independent of the amount injected, and sharp cutoff of the injection.

—Art Erikson, Paris Bureau



CURVED SIDE WINDOWS highlight the German Ford's new Taunus 17M for 1961. They provide more width at shoulder height; the extra 4½ in. makes the 17M a comfortable car for six, Ford says. And the aerodynamic lines of the new body are an attempt at better performance even though the engine remains essentially unchanged. For the 1700-cc, 67-hp engine option, top speed is 90 mph, with acceleration from 0 to 63 mph in 18 seconds.

Pentagon Seeks Streamlining of Engineering-data Retrieval

NEW YORK—With the cost of military engineering documentation soaring past the $2 billion-a-year mark, Pentagon officials warn that the US must streamline its systems for storage and retrieval of engineering data (*PE*—Aug 1 '60, p 15), or be snowed under.

A representative of the Armed Forces Supply and Support Center's Standardization Div, W. S. Hutchinson, reported that the military services alone turn out 6 million engineering data drawings a year, that more than 50 million are on file, and that more than 1 billion copies of these drawings are reproduced annually.

"The defense operation is getting bigger, and more complex," Hutchinson told a meeting of the American Standards Association here. "We depend on thousands of contractors, subcontractors and vendors to design and produce new weapons and supporting materials. Only by standardizing and coordinating retrieval and storage methods can we narrow the growing multitude of approaches to documentation." ■

New Test Will Find Flaws in Rocket Casings

SAN FRANCISCO—Promising research in the creation and testing of surface cracks in high-strength steel may soon be applied to the Polaris program as a result of work being done by the Stanford Research Institute for the Navy.

Cracks can be incipient in the metal—or caused by welding. In rocket casings, conventional pressure techniques for detecting such cracks have certain inherent disadvantages because of the properties of cracks in high-strength, low-alloy steel. Small surface cracks can be perfectly harmless; however, pressure invariably causes them to enlarge. Beyond a certain point this quickly develops a split, causing failure of major malfunction of the missile. Pressure testing frequently enlarges a crack almost, but not quite, to the splitting point; then, the very next pressure applied—in flight—can cause a breakdown.

ADOPTS SPARK-MACHINING METHOD

SRI metallurgists sought to create reproducible "natural" surface cracks in steel used in large-diameter, thin-wall vessels subject to great internal pressures. They finally decided on a technique that calls for spark-machining a thin slot in metal similar to the brittle, high-strength, low-alloy steel used in rocket casings. Metal is cooled to increase brittleness, then impacted at high speed with a steel stud. The spark-machining device, using a tantalum-ribbon electrode, machines various-size slots which measure 4 mils wide, 3 to 30 mils deep, and about 1 in. long.

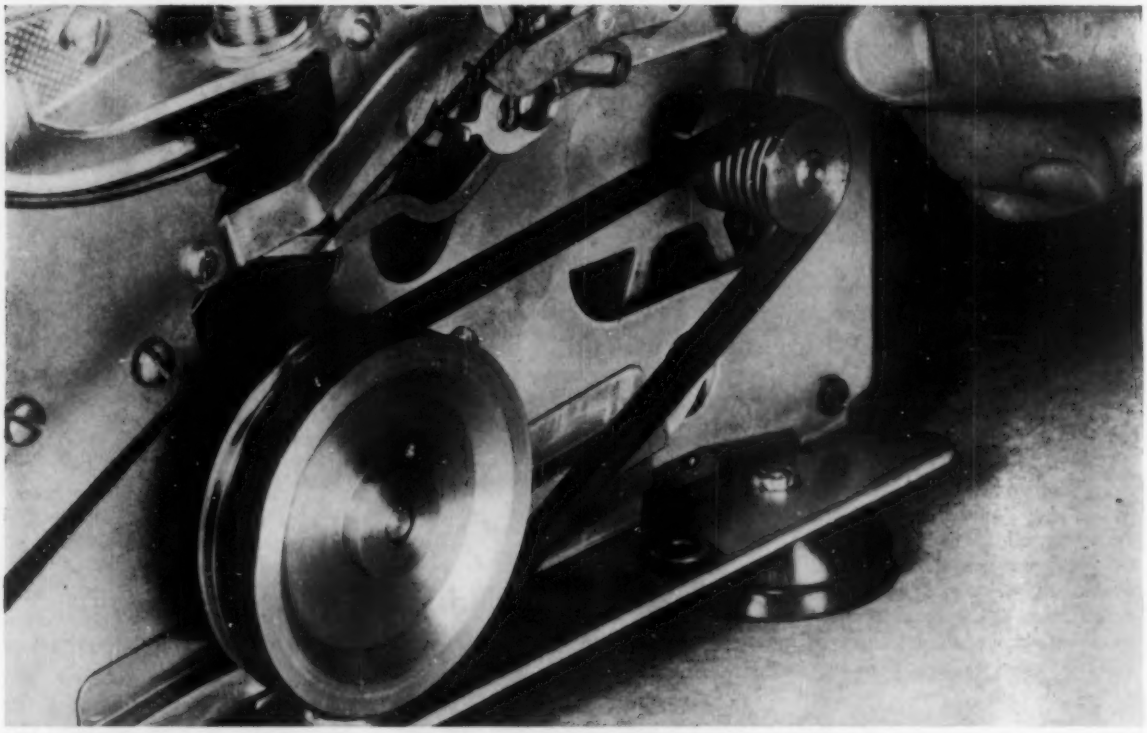
Slotted pieces of metal are then immersed in liquid nitrogen until boiling stops, indicating metal has reached the temperature of the liquid (−320 F). Removed from the nitrogen, the specimen is then positioned with its slotted side down, and a steel stud is fired into it directly behind the slot. A conventional Ramset fastener, whose explosive cartridge fires the stud at a speed of 600 to 900 fps, does this job.

The result is a crack which passes all requirements of a "natural" crack in the surface of the metal. Tapering and semielliptical in shape, a typical crack size attained was 1½ in. long and from ¼ to ⅝ in. deep. This is repeatable: Machining the same-size slot and firing a stud with the same charge produces the same-size crack.

SRI's next step will be analysis of the properties of surface cracks in hopes that the findings can be applied to all high-strength steel used under heavy stress. Aerojet-General Corp is sponsoring the project.

—Don Winston,
San Francisco Bureau

Designers think of R/M first for asbestos, rubber,



R/M POLY-V® DRIVE "J" OFFERS ADVANTAGES NEVER BEFORE POSSIBLE

Design advantages sought for years for small machinery drives are now available exclusively in Poly-V Drive "J"—utilizing a single parallel V-ribbed belt running on space-saving sheaves grooved to mate precisely with the belt ribs. Only R/M Poly-V "J" offers . . .

- **Silent, vibrationless drive operation**
- **No splice on traction surface**
- **Requires less space—is cooler running**
- **Designed especially for small pulleys—as small as .8" diameter**
- **Positive groove tracking—will not wander or run off sheaves**
- **Will operate in any position and on ¼ turn and mule drives**
- **Ideal for serpentine or tandem drives**
- **High RPM and belt speeds**
- **Highly efficient**
- **Long life with either inside or outside idlers**
- **Exceptionally small mounting clearances and take-up. Permits reduction of housing and cover casting size**
- **Absorbs shock—gives overload slip protection against machine damage**
- **Does not lose efficiency with wear—gives longer life for belt and sheaves**
- **Heat and oil resistant—requires no lubrication or belt dressing**
- **Exceptional flexibility—operates easily with midget motors**

(Patented U.S. and foreign countries)

Engineered Specially for—

Small Sheaves and Short Centers Wherever Balance, Reliability and Silent, Vibration-Free Performance are required.

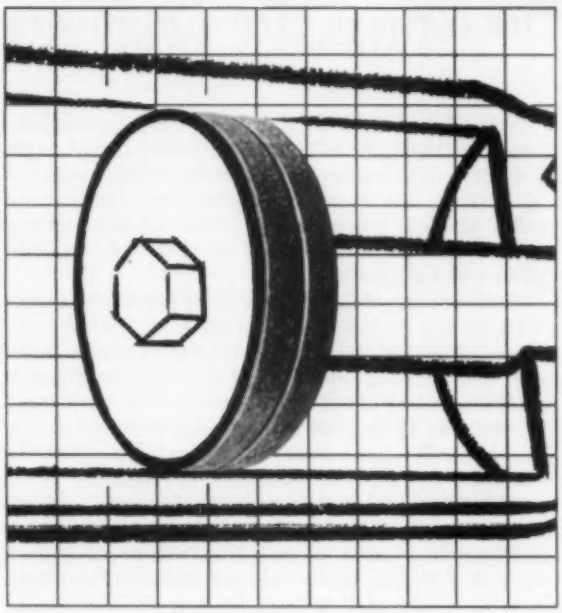
MORE power in LESS space than conventional V-Belt Drive with no matching or turnover problems. Write for Bulletin M142.

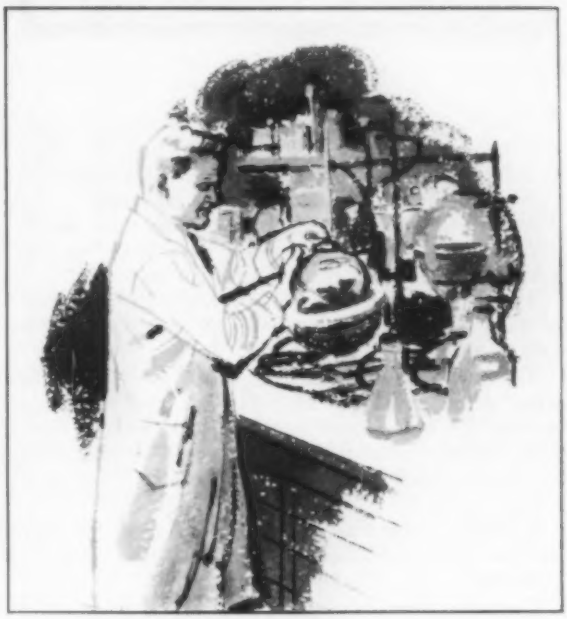
For medium and heavy duty drives R/M Poly-V is available in the larger "L" and "M" Sections. Write for Bulletin M141.

Wherever your problems involve Power Transmission Drives, V-Belts, Flat Belts, rely on R/M Products and Engineering Services.

Write today for free booklet shown: full details on a wide variety of industrial rubber products. Manhattan Rubber Division, Raybestos-Manhattan, Inc. Passaic, N. J.

sintered metal, and engineered plastic products





R/M CAPABILITY

develops precision-molded piston cups for perfect seals that last and last

You can be sure of minimum friction, highest resistance to extrusion, and positive sealing action with R/M precision-molded piston cups. Compounds have been carefully developed by R/M's chemists to provide maximum service in a wide range of applications. Careful quality control assures dimensional uniformity, clearly defined contours, and cleanly trimmed edges.

Two types are available: R/M 1400 Series, manufactured from duck and synthetics; R/M 1501, from asbestos fabric and synthetics. Both are custom made to fit specific applications. Diameters range from ½ to 12 in. They can be furnished in varying degrees of hardness for pressures to 1500 psi. And R/M's vast experience in designing and manufacturing packing and gasket materials is at your disposal. Send us data on your application.

PACKINGS

Write for free brochure giving complete information on R/M Molded Hydraulic and Pneumatic Packings. Packing Division, Raybestos-Manhattan, Inc., Passaic, N.J.

ADHESIVE PROBLEMS SOLVED HERE

Here in the Raybestos-Manhattan adhesives laboratory at Bridgeport, Conn., our engineers can solve even your most difficult adhesive problems.

R/M manufactures a wide range of Ray-BOND® adhesives. For special requirements, R/M will tailor special adhesives . . . designed to meet your particular manufacturing techniques, the demands of the materials you are using, and the service conditions of your product.

Take advantage of R/M's more than 20 years of experience in the production of bonded assemblies and the manufacture of adhesives, coatings and sealers. Why not call on Raybestos-Manhattan engineers today, without obligation, and ask them to prove how they can help you cut costs, speed production, and simplify fabrication and assembly operations.

ADHESIVES

New R/M Bulletin No. 701 contains helpful engineering information on Ray-BOND adhesives, protective coatings and sealers, casting, encapsulating and potting compounds. Write for a copy today. Adhesives Division, Raybestos-Manhattan, Inc., Bridgeport, Conn.

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • Paramount, Calif. • No. Charleston, S.C.
Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

CIRCLE 221 ON READER SERVICE CARD

POINTS OF VIEW

THE QUESTION: *Are Engineers*

I have been disturbed to observe, in my editorial travels this election year, a resurgence of what might be called 19th century "Mugwumpery." Too many folks bespeak an easy superiority toward the issues and candidates of the day; too many claim they can't make up their minds. Too many, it seems to me, "have their 'mugs' on one side of the fence, and their 'wumps' on the other."

And the prime reason I am disturbed is that too many of today's Mugwumps sitting on the fence have slide rules in their hands.

The reason for this state of affairs can, I think, be stated in the following paradox: In a day when technology assumes an increasingly controlling role in our lives, technologists—scientists and engineers—are becoming increasingly indifferent to the social problems their technology evokes.

Let's take a few examples. In each of these the technologist plays a responsible role of creation, then an irresponsible role of indifference.

First, the American automobile, regardless of what anyone says about its style, remains the classic example of imaginative, cost-conscious engineering against heavy manufacturing odds. Yet urban congestion and highway safety are two of our most pressing national problems, about which Detroit has yet to raise its voice above a murmer.

Second, the most spectacular achievement in manufacturing has been, to my mind, the marriage of the computer and the machine tool to create a world of automatic manufacture and assembly that is breathtaking in its portents for future productivity. Yet the creators of this shotgun wedding have largely left the emerging problems of unemployment, worker retraining and increased leisure time to the sociologists.

Third, the American standard of living is second to none and will continue so, in my estimation, for several decades to come—the Soviet thrust not withstanding. We must face the fact, nonetheless, that the vitality of our society depends—in large part—upon conspicuous consumption, with its concomitant unknitting of the sleeve of national purpose. We may rightly ask: how often do the creators of such plenty remind a diverted, buying public of the big human problems confronting a burgeoning population?

Fourth, the Manhattan District project of World War II has been rightly adjudged an engineering miracle. Yet few of us could give, 15 years after Alamagordo, any accurate estimate of an H-bomb's effect on an urban area like New York. Unless the progenitors of atomic energy supply us with such facts, how can serious proposals for survival—like Gov. Rockefeller's recent one on bomb shelters—receive a fair hearing?

I think, therefore, that it is important we inquire into the root cause of the engineer's relative indifference to public affairs. The key seems to me to lie in the lopsided way he applies the four major characteristics that mark him as a standout among men.

Now, if these four characteristics—curiosity, creativity, honest, and versatility—are directed mostly inward to the product or job environment, then the paradox sharpens. If, however, the engineer recognizes the viability and utility of these talents in the public sphere, and consciously exercises them outward from the job, then the paradox can be resolved.

Here are some of the steps engineers can take to assume a greater role in public affairs. Some stem from the outward projection of the technologist's special talents; others arise from his nature as a political animal. Some will elicit ready acceptance; others may provoke debate. All of them, I believe, are in harmony with the dual nature of citizenship in our Western culture: the citizen has a right to be consulted, but a concomitant duty to contribute to the consultation.

First step is a sort of professional stock-taking, a critical examination of your own job. It is well worth doing? Does the end product or service rendered contribute or detract from the public weal? Is the product or service an honest one, honestly marketed? These questions may seem ingenuous at first, but I firmly hold to the Socratic injunction: "The unexamined life is not worth living." If you are going to begin organizing consent and support for action in the common good—and this, simply, is what politics is all about—then such an inward look at the outset is worthwhile.

Secondly, inform yourself of the facts in a given public controversy, just as you gather data when choosing among possible alternatives in an engineering decision. Simplest method is to read widely on events of the day—a comprehensive daily newspaper, a capsulizing weekly magazine, a reflected monthly journal, as many books as interest you. Of course, this will give you plently of opinion along with the facts, but your discriminating powers will quickly sharpen.

Third, know your society, its history, the structure of its government and the basic issues that have tested it. There is a sound reason for such immersion in the history of our country: it lends perspective and understanding to the contemporary scene which, at best, seems flat and harsh as we rush about our daily tasks.

Debate the issues in my fourth suggestion. Once you have the facts and some background against which to interpret them, you are in a position to start searching for a solution to the problem confronting you or the community. One of the greatest tools in this search is debate—discussion that leads to action. I add this qualifier because it seems to me that discussion for discussion's sake is a perfect example of a peculiarly American preoccupation with the rituals of democracy.

When I urge debate upon you, I am not thinking of quickly choosing sides and arguing. I am thinking of serious inquiry into the alternatives. As in engineering, the choices in public affairs are seldom black and white. I would urge an initial detachment before you rush in with your arguments. Don't accept the first solution that

'Too Good' for Politics?

FORD R. PARK, *associate editor*

occurs to you. If you have the sense to check hydraulic drives vs electric drives in an engineering design, have the sense to check, for example, a bond issue scheme vs a pay-as-you-go plan in a municipal improvement situation.

Fifth, use your logical faculties to bring direction and precision to civic inquiry. As an engineer, your intellect has been honed to the observation of fact and the deduction of right action therefrom. Even the most casual attendence at town council meetings, school board meetings and so on will convince you that logic is a scarce commodity these days. Part of any orderly assay of a civic problem is a firm resolution to spurn emotional arguments as decisive.

Notice I have added the qualifying words "as decisive." Emotion cannot be excluded from public inquiry, nor should it be—in my judgment. Still, the trend today as our civic problems become more knotty is to let emotion sway the argument unduly. The danger is sharply drawn by Dennis Brogan in a new and lively book, Citizenship Today: "Emotional decisions disregard the long-term price by gratifying short-term resentments."

Sixth, participate in public affairs where your talents as an engineer count most. I have mentioned debate and discussion, but I have in mind here the more non-partisan arenas of activity: the planning boards, zoning boards and the like. These groups seek detailed knowledge to guide action and can use your expert knowledge along with your facility for analyzing complex problems. This kind of participation is close akin to committee work within technical socities, and many of you know how important and rewarding that can be. Be forewarned, though, that the operative word is "work," and working simultaneously on society committees and civic advisory groups requires the energy of Hercules and patience of Job.

How about partisan political activity? Here the human effort reaches not only for the correct solution to a given problem, but also for the power to implement this solution. Facts now become subject to judgment and interpretation, with the philosophy and character of the candidates and parties coloring the solution. This is as it should be, but I suggest that under these circumstances the engineer's special talents no longer lend him quite the advantage he had in non-partisan civic activity.

I think, then, that the decision to become active in one party or the other hinges more on your personal interests in political philosophy and program than on any conviction that engineering talents are of particular use. It is good, though, to keep in mind the old observation that "politics is the art of the possible." This means compromise, and any product designer worth his paycheck knows that word. In this pluralistic society of ours, compromise is the lubricant that makes democracy run more smoothly. If party man you must be, then don't let dogma clog the oil ports!

My next suggestion concerns the men you select to represent you, and how you keep them on their toes once elected. Insist on sound representatives who can think for themselves on the broad issues of the day. This is sometimes difficult to do in such a huge country with such diverse, regional interests. I commend to you Edmund Burke's view. Addressing the electors of his Bristol constituency in 1774, the British parliamentarian put it this way: "Your representative owes you, not his industry only, but his judgment; and he betrays instead of serving you if he sacrifices it to your opinion." In critical times it is not enough to accept men who, in Demosthenes' phrase "try to please the citizens rather than to tell them what they need to hear."

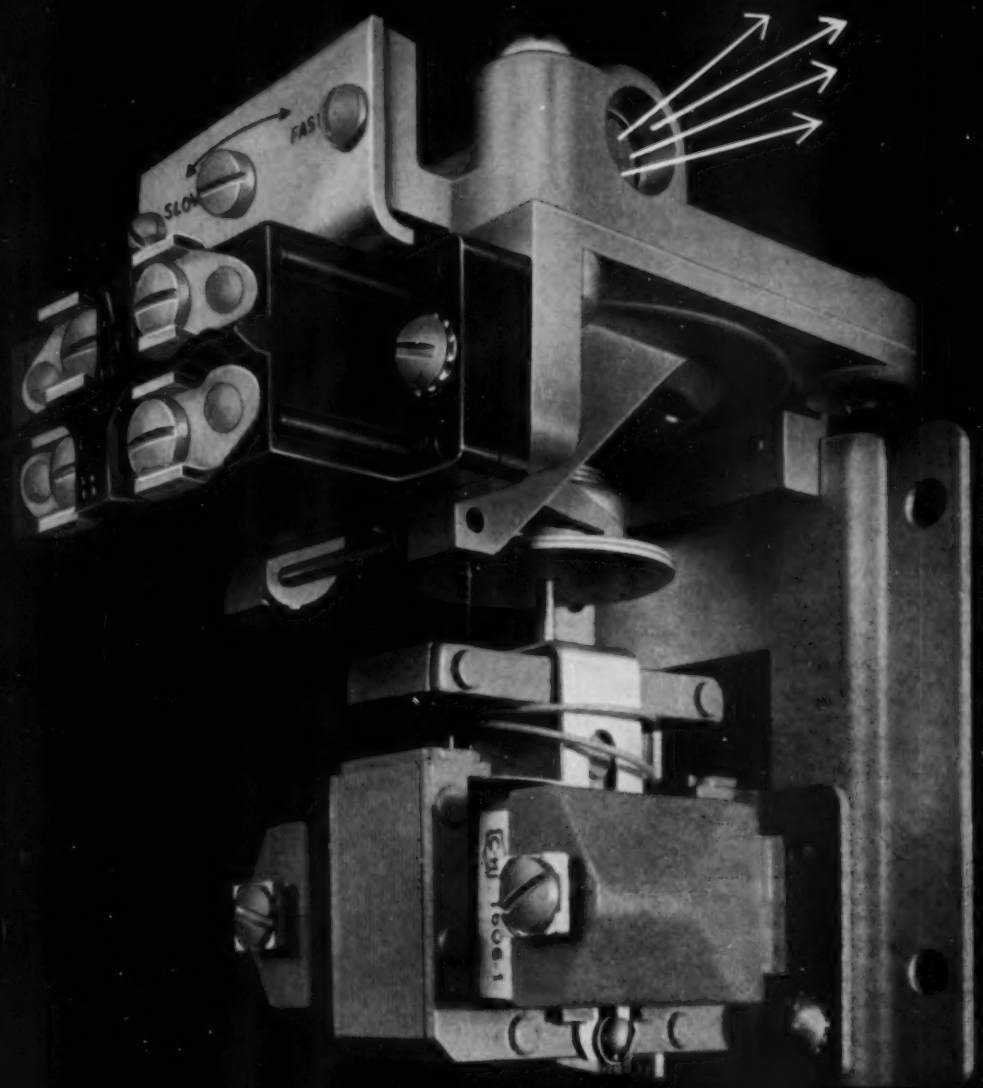
Getting sound men is a matter of studying their records, listening to them talk, voting in primary elections, and voting in the final contest. More about voting in a moment. Assuming the representative of your choice wins, keep after him with letters expressing your views on matters of interest. If your representative displays little capacity or inclination for reasoning out the issues in this manner, it's time to replace him with one who will.

Patience is the eighth virtue I would commend to you in your pursuit of excellence in public affairs. As engineers, you seek immediate solutions to problems; in politics, it may take a generation or two to resolve an issue—agricultural surpluses, for example. American democracy is an astonishingly stable mechanism, with excellent feedback, but somewhat mushy controls. It can correct itself, by vigorous and patient political action, as we know from the vast Populist movement in the 1890's. But reform and innovation both take time to accomplish; consent must be organized, rather than orders given, as in engineering. So participate—but patiently.

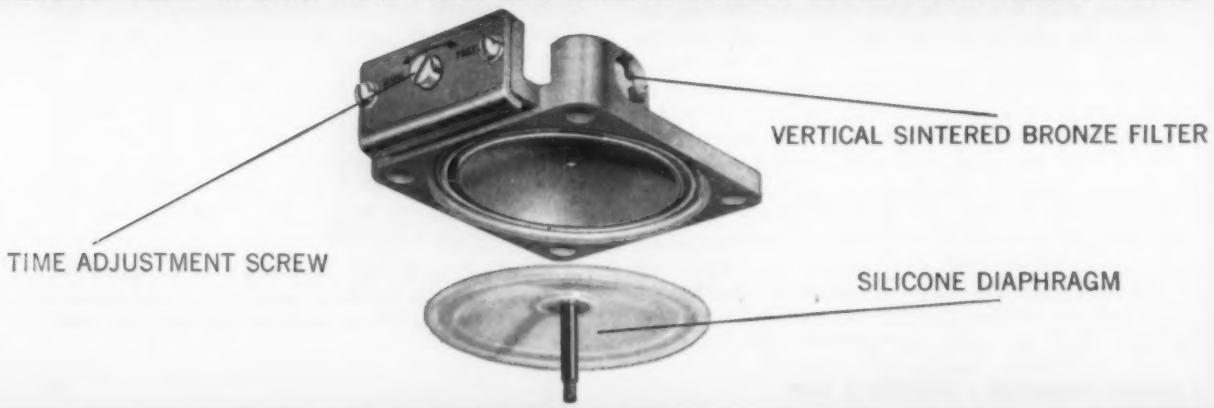
Vote regularly—but with discrimination, is my last suggestion, and it seems almost too obvious to discuss. What engineer with normal curiosity, intellectual honesty, and flair for creation would turn away from this most creative of acts in the public sphere? Yet, voting in America is vastly complex: a single ballot in a Presidential year can contain perhaps a dozen or so names on national, state, county and village level. We insist on electing judges and coroners, as well as Presidents and Senators. There are often propositions to be decided. With all these decisions to make, no wonder only about 50% of the electorate votes. I suspect a good share of the other 50% simply conclude they don't know enough to vote with discrimination, and prefer not to muddy the results with their ignorance. This is the only valid reason I can see for not exercising your franchise—but for an engineer this is a pretty weak reason. To choose it is to open the door to indifference—and to Plato's indictment of some 2300 years ago: "The punishment wise man suffer for indifference to public affairs is to be ruled by unwise men." In 1960, this might be paraphrased thusly: Don't be a Mugwump with a slide rule!

The above Points of View was excerpted from a recent speech given by Mr. Park before the Fort Wayne Engineers Club. An earlier article of related interest was "Science and Politics Don't Mix—Or Do They?" June 1 '59, p 28.

NO CHECK VALVE! Air cleans filter as it exhausts through the vent. No check valve to clog and cause trouble.



EXPLODED VIEW SHOWS HOW NEW DIAPHRAGM DESIGN ELIMINATES CHECK VALVE



New! A Cutler-Hammer one-minute pneumatic timer that eliminates the troublesome check valve!

Unique diaphragm design makes timer more accurate and dependable than any other

The new Cutler-Hammer one-minute Pneumatic Timer, by eliminating the conventional check valve, does away with failures caused by dust.

Using a silicone diaphragm, this timer pulls fresh air in through a filtered vent, and on the exhaust stroke blows away any dust that may have collected on the surface of the filter. No chance for dust to affect accurate timing or make the timer inoperable. The silicone diaphragm works equally well 150°F above zero or 45°F below zero.

No other timer is more accurate. It adjusts easily from .2 seconds to 60 seconds with a 7½-turn screw that provides precise adjustment to the desired time setting. All you need is a screwdriver. And, it can be changed from "on delay" to "off delay" in seconds. Smallest electrical dimensions of any one-minute timer, too. Call your Cutler-Hammer distributor for full details or send for Publication L071-W249.

What's new at Cutler-Hammer?

You can see the big change at Cutler-Hammer wherever you look. New, better products. New, expanded engineering staff and facilities. New added plant capacities. All done to help you meet the big opportunities of this decade.

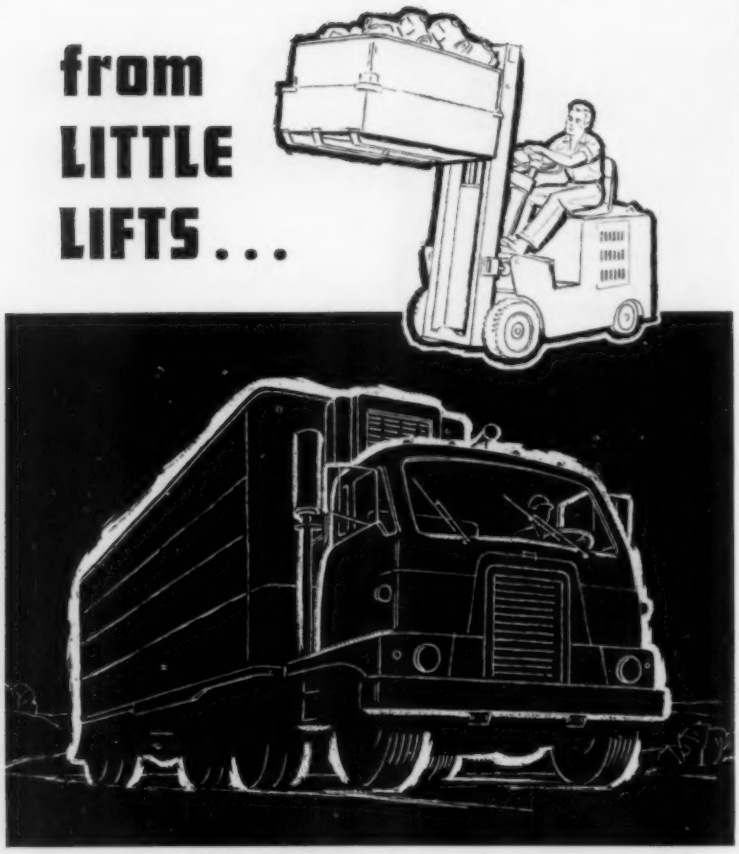
If you're planning ahead, we'd like to show you how our talents and experience in electrical control could help you. Contact the nearest Cutler-Hammer sales office.

WHAT'S NEW? ASK...

CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.

from LITTLE LIFTS...



to SUPER SEMIS

Both are driven by Rockford Spring-Loaded Clutches. Rockford offers today's design engineer an ultra-wide range of proven power controls for automotive, agricultural and industrial machinery. Rockford's complete engineering design service is available to you at no cost or obligation. All clutches are quality-built and thoroughly tested for enduring dependability . . . customers stay customers. Write today for illustrated brochure.

SPRING-LOADED ROCKFORD CLUTCH

ROCKFORD CLUTCHES

ROCKFORD CLUTCH DIVISION — BORG-WARNER

209 CATHERINE ST.
ROCKFORD, ILLINOIS

ROCKFORD BW CLUTCH

Export Sales
Borg-Warner International
36 So. Wabash, Chicago, Ill.

READER TO EDITOR

Medical Enginering

To the Editor:

I have read with interest your very fine article, "Medicine Consults the Design Engineer," Sep 19, p 81. I wish to point out, however, that there are advantages to the use of an engineering group on a formal, contract basis wherein work on a given project is full-time and the result of a coordinated team effort. We here at Cordis have felt the need for this type of developmental effort, feeling that the research doctor's time is better spent with the clinical aspects of his problem, while the engineering aspects of his needs are more satisfactorily consummated in an engineering atmosphere, heavily oriented to medical qualifications. —WILLIAM P MURPHY
President, Cordis Corp, Miami

To the Editor:

You have done a fine job in bringing to light the frustrating situation concerning new and adequate instruments and equipment for the medical profession. New surgical techniques require new instruments to be continuously created; existing, old-style equipment just will not do. Engineering has been applied to most every phase of our society today; why then, could it not be applied to medicine, providing it was applied with system instead of haphazardly, resulting in additional frustration to the men involved?

It was mentioned that a medical-engineering firm is getting underway—"founded by Dr Selwin McCabe"—and that the group proposes to assemble a team of doctors and technologists to work on problems. A firm, specified by its charter to function specifically for the purpose of medical engineering, more properly "anatomic engineering," is already in existence, and was founded in 1954. Since that time, it has functioned continuously as a "creative design" firm for the investigation, design and development of new and original instruments and equipment for the medical and dental professions.

An existing situation requiring assistance was also mentioned—Dr Burdick's light problem. From the information supplied, a solution seems possible. Could the doctor's address be obtained?

—WM C KNOX JR
President, Knox Instruments Inc
Seattle

• Dr Burdick can be reached at the Cleveland Clinic, 2020 East 93rd St, Cleveland—Ed.

A Question of Professionalism

To the Editor:

Your "Horizons," Sep 5, p 39, outlined "Three Steps to Professionalism." After reading this editorial, I am not sure whether you refer to steps which are meant to be taken forward or backward. As you properly indicate, the concept that a professional person pursues his occupation "largely for others and not merely

for one's self" is indeed a "sticky one." In fact, it is too sticky to be acceptable as any reasonable basis for professional development.

In substitution for this alleged "characteristic," I propose that you consider the honest acceptance of a straightforward trait which does exist as a primary motivating element in the makeup of our most professional and creative individuals. This is the desire for personally satisfying achievement, totally independent of others. In point of fact, men with this characteristic have been responsible for technological advances, establishment of our industrial world, and all true progress which has taken place on this earth.

The sermon of the bricklayers is indefensible. Its "Maginot Line" is the association with a church. By relocation of the construction site to that of a new gambling house or equivalent, its fallacy becomes obvious. A professional bricklayer would lay bricks because he liked to; he would be a good bricklayer and personally enjoy those challenging jobs which would require creative methods of masonry.

Altruism has been practiced and preached by only the noncreative. It is the doorway to the room of socialism, which holds no space for professionalism. Brandeis was wrong 48 years ago and is still wrong today. His utterances would better have been left in their grave.

—Allan W McCoy
Scottsdale, Ariz

COMING EVENTS

NOVEMBER

8-11 . . . . Society of Die Castings Engineers, 1st National Die Casting Exposition & Congress, Detroit Artillery Armory, Detroit

11-12 . . . . American Society for Quality Control Aircraft and Missile Conference, Lord Baltimore Hotel, Baltimore

14-17 . . . . American Institute of Electrical Engineers, Magnetism & Magnetic Materials Exhibit, Hotel New Yorker, NYC

14-18 . . . . American Society of Tool and Manufacturing Engineers, Western Engineering Conference and Exhibit, Los Angeles Memorial Sports Arena, Los Angeles

16-18 . . . . Porcelain Enamel Institute, 22nd Annual Shop Practice Institute, Univ of Illinois, Urbana

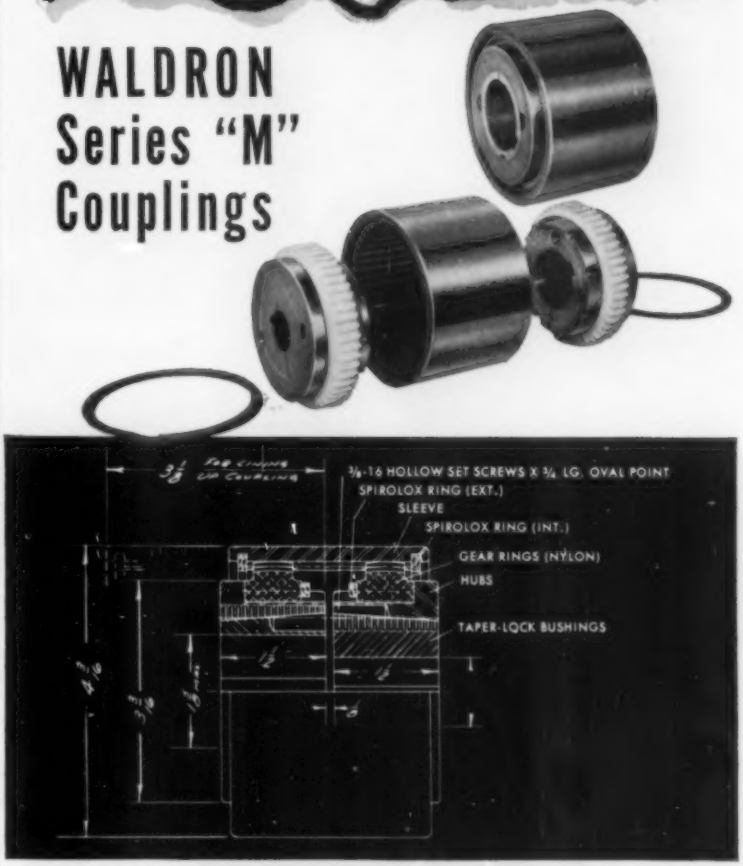
27-Dec 2 . . . . American Society of Mechanical Engineers, Winter Annual Meeting, Salter Hilton Hotel, NYC

DECEMBER

5-8 . . . . American Institute of Electrical Engineers, National Conference on Application of Electrical Insulation, Conrad Hilton Hotel, Chicago

design facts....on

WALDRON
Series "M"
Couplings



The new Series M couplings—with nylon gears and steel sleeves—need no lubrication. Equipped with Taper-Lock bushings—each coupling size can accommodate a range of shaft sizes. For instance, the 162M, now available, will take shafts from ½" to 1⅝" with proper size Taper-Lock bushings, and up to 2" without the bushings. Hubs are machined from bar stock and the one piece sleeve is made of steel. This design means a smaller, light weight coupling that is easier to install and maintain and yet can transmit the necessary power. Size 162, Series M gear couplings can be used for continuous operation up to 5000 rpm at torques up to approximately 2000 inch pounds.

WRITE FOR CATALOG

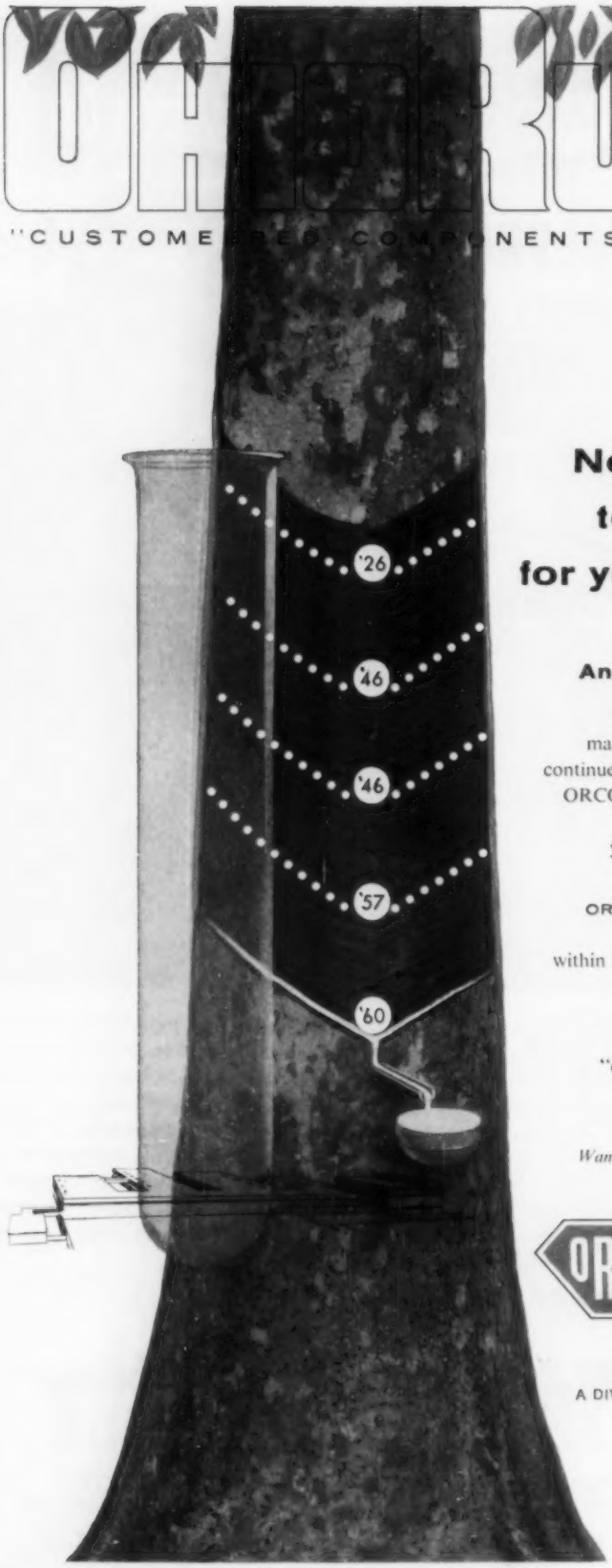
WALDRON Couplings

WALDRON-HARTIG DIVISION
MIDLAND-ROSS CORPORATION
BOX 791, NEW BRUNSWICK, N. J.

CIRCLE 29 ON READER SERVICE CARD

OHIO RUBBER

"CUSTOMEERED COMPONENTS BASIC TO INDUSTRY"



New plant growth to tap for your rubber needs

And you made it possible!

Ohio Rubber's history of plant growth and manufacturing expansion dates back to 1926—continues through 1946 and 1957. And, in late 1960, ORCO opens its new Fort Smith, Arkansas plant—dedicated, as with the others, to serve you better—to supply your increasing needs for custom components.

ORCO SUM TOTAL: 5 major, geographically strategic plants . . . 1,200,000 square feet within 143 acres . . . over 2000 trained employees . . . diverse products of natural and synthetic rubber, neoprene, polyurethane, flexible and rigid vinyl . . . "customer-friends" like you across the board in industry, nationwide.

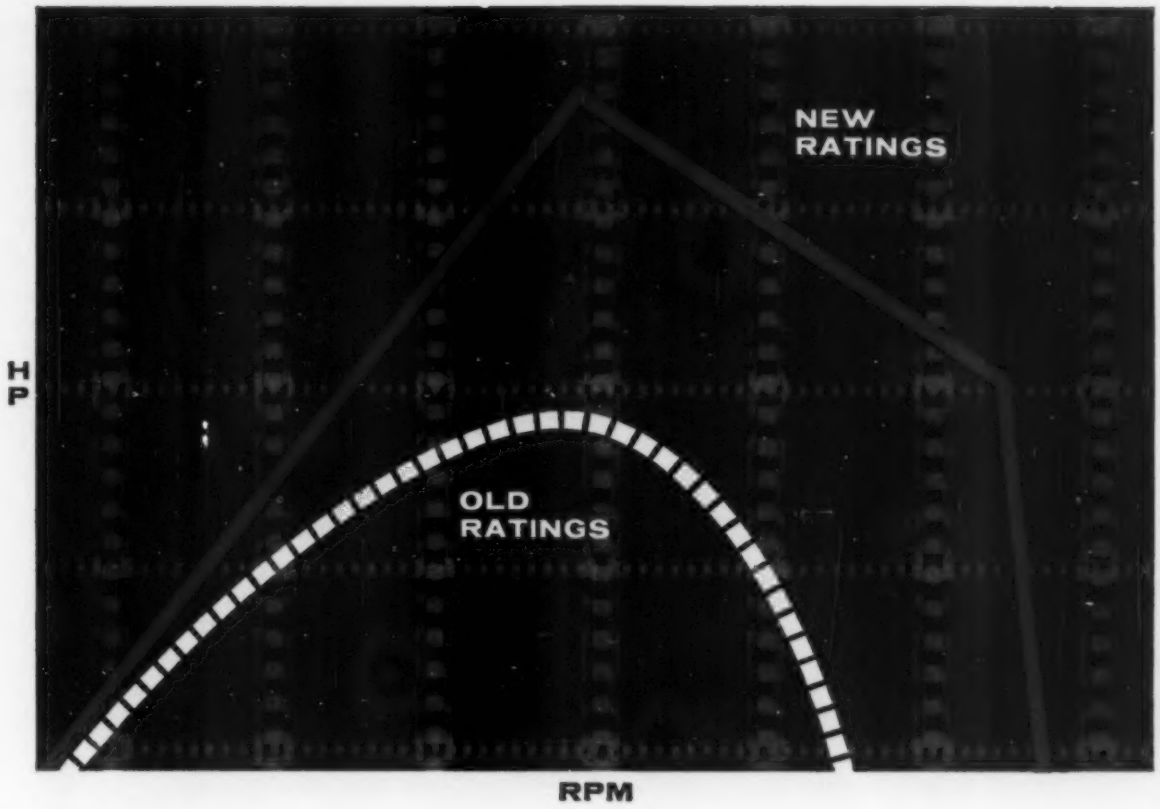
Want to know more about Ohio Rubber? Write today for our "Customeering" bulletin.

MP-200

ORCO THE OHIO RUBBER COMPANY

General Office • Willoughby, Ohio • WHitehall 2-0500

A DIVISION OF THE EAGLE-PICHER COMPANY



NEW HORSEPOWER RATINGS FOR REX ROLLER CHAIN

Break the Barriers on Speed and Capacity

Now you can use Rex Roller Chains for efficient operation at horsepower capacities and speeds generally considered impractical in the past. New ratings, made possible by quality improvement and proved in the most exhaustive laboratory and field tests, now open fields of application for the imaginative designer.

The new horsepower ratings were developed by the combined efforts of the Association of Roller and Silent Chain Manufacturers. Rex Engineers took an active part in this program. Here are the facts:

PRODUCT IMPROVEMENT PROGRAM

For some time, Rex Engineers have been engaged in a program of continuous product improvement. Such developments in design and manufacturing as guided piercing and re-piercing of link plate holes...precise control of pin, bushing and roller diameters...precision interference fits of pins and bushings in link plates...accurate control of pitch...oil holes in bushings for increased access of lubrication to live bearing areas...have resulted in greater horsepower capacity for Rex Roller Chains.

APPLICATION EVALUATION PROGRAM

Through years of extensive work both in conjunction with the Association of Roller and Silent Chain Manufacturers, and in CHAIN Belt laboratories and in the field, Rex Engineers have helped acquire a more intimate knowledge of the load and speed requirements of roller chains under actual service conditions. Such testing programs as field dynamic load tests using strain gauges on actual operating chains...the relationship of proper lubrication and speed as it affects galling...have led to successful applications of Rex Roller Chains at greater loads and speeds than previously considered practical.

For all the facts and your copy of the new horsepower ratings, write CHAIN Belt Company, 4715 W. Greenfield Ave., Milwaukee 1, Wis. In Canada: CHAIN Belt (Canada) Ltd., 1181 Sheppard Ave. East, Toronto.

REX®

CHAIN BELT COMPANY

THIS PIECE OF KENNAMETAL* REDUCES NOZZLE COST 90%

A can manufacturer replaced stainless steel nozzles with Kennametal tungsten carbide nozzles in a can lid sealing operation — and gained these results: increased nozzle life 18 to-1 . . . increased pressure from 55 to 105 psi . . . improved quality and coverage of seal . . . reduced nozzle cost 90%.

Kennametal carbides have many properties for many applications—including some that may be the answer to your requirements.

PROPERTIES: Kennametal hard carbide alloys have high hardness; resistance to abrasion from 10 to 100 times greater than steel; high resistance to corrosion; high torsional, compressive, and tensile strengths; extremely high YME, up to 94 million psi compared to steel's 30 million psi. Kentanium* titanium carbides have similar properties plus light weight; resistance to oxidation at temperatures of 2200° F. and above; and highest stiffness-to-weight ratio of any metal or alloy.

APPLICATIONS: Booklet B-666, "Proven Uses of Kennametal and Kentanium" describes 80 different applications of these hard carbide alloys. Write KENNAMETAL INC., Dept. PE3, Latrobe, Pa.

*Trademark 33541

INDUSTRY AND KENNAMETAL ...Partners in Progress

FOR YOUR INFORMATION (personal)

Coffee break for care-worn motorist

A pushbutton coffee dispenser specifically designed for installation in motels—to provide free coffee on an instant basis—is the latest innovation for the travel-weary. The self-contained unit requires no plumbing connections (just fill the tank with water and lock it), operates on 100-v ac current. Coffee, cream, and sugar packets are provided in sealed cups. The dispenser holds 4 cups of water, has a 600-watt heating element, weighs 7 lb complete. Courtesy Products of San Diego makes it. Kaiser Steel publication editor Gene Drossel found and photographed it.

Over the hump with Pythagoras and Euclid

An attractive series of booklets, originally designed to help teachers present mathematics, not just as numbers and formulas, but as a way of thinking and a tool for discovery, is now available to help you tutor your children in algebra, geometry, network theory, and the laws of chance. Each booklet (7 of a proposed series of 12 have so far been published) is 40 to 60 pages in length, paperbound, 6 by 9 in., and priced in the 50¢ to 65¢ range.

Titles now available: Invitation to Mathematics; Topology; The Pythagorean Theorem; Sets, Sentences, and Operations; Understanding Numeration Systems; Number Patterns; Fun With Mathematics. Coming up: The World of Statistics; Shortcuts in Computing; The World of Measurement; Adventures in Graphing; All About Computing Devices. The publisher: Webster Publishing Co, 1154 Reco St, St. Louis 22.

To manipulate your mail

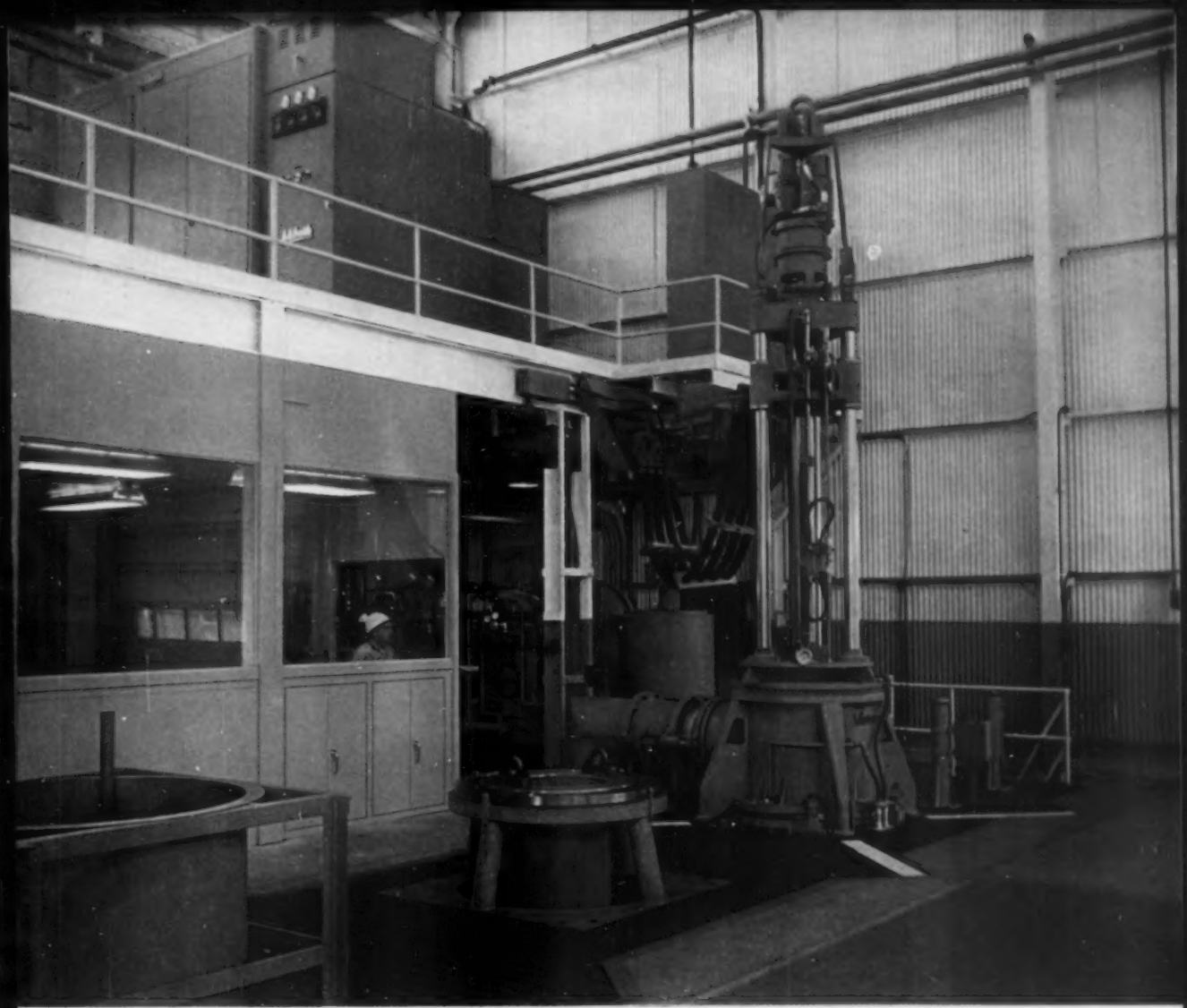
A letter-opener that acts like a bar-operated hole-puncher, and a postage meter that's claimed to be "the first to print directly on any size envelope or package," are among the latest laborsavers for the office.

The letter-opener slits the envelope when you push down on the spring-held bar. Made by New Canaan Engineering Co, it's available in several colors, with or without desk pens attached. Prices are $21.95 and $19.95.

The postage meter (see photo) features an automatic inking mechanism and is adaptable for a manual or electric-drive letter sealer. Tele-Norm Corp makes it, leases it for $8.50 a month.

BANTAM POSTAGE METER weighs only 5 lb, can print directly on packages as well as letters, Tele-Norm says.

Also available, for home or office use: a new-model postal scale that will handle weights to 4 oz, is pencil-shaped and spring-operated. Postamatic Co, Philadelphia 41, sells it for $1. —ARG



SPECIAL QUALITY STEELS AVAILABLE AT STANDARD

One of the largest vacuum arc remelt furnaces in the country—the first of four to be installed—is now in operation at Standard Steel Works Division of Baldwin-Lima-Hamilton Corp. This new facility, together with electric melting furnace and vacuum degassing equipment acquired recently, now makes it possible for Standard to deliver "laboratory-quality" steels in production quantity.

Standard is now capable of producing vacuum remelt quality ingots, up to 30-inch diameter, in all of the super-strength steels and special alloys requiring exceptional quality. Standard continues to offer superior service and superior materials to American industry. We especially welcome forging and ring inquiries for tools, missiles, turbines, bearings and similar applications for super-strength, heat-resistant, corrosion-resistant and other special alloys.

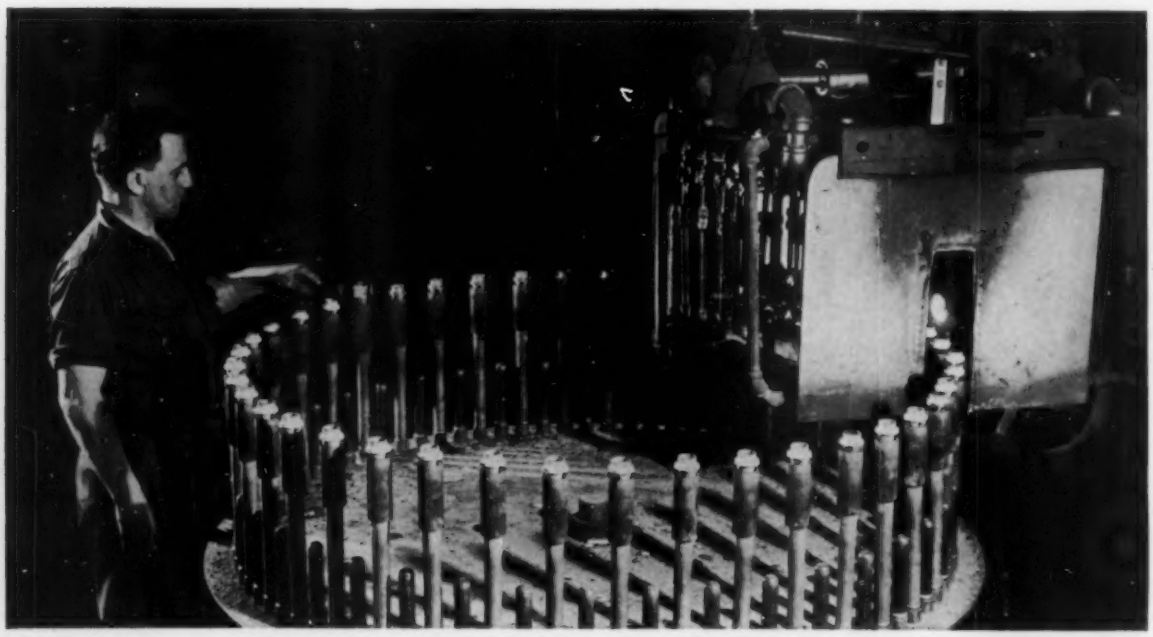
Standard Steel Works Division
BALDWIN · LIMA · HAMILTON

BURNHAM, PENNSYLVANIA

Rings • Shafts • Car wheels • Gear blanks • Flanges • Special shapes

BALDWIN BLH LIMA-HAMILTON

Every Hour M. S. Little Brass Goods Company Makes 650 Appliance Fittings Better With **HANDY & HARMAN SILVER BRAZING**



Rotating jig showing mounted assemblies entering and leaving gas-air furnace.

Left– brazed assembly. Right– components with preform ring of EASY-FLO *45.*

This Hartford, Connecticut, company makes—in volume—an assembly that goes into the overflow system of household appliances. The assembly consists of brass tubing and a machined brass casting. The two components are joined by a preplaced ring of Handy & Harman EASY-FLO 45 silver brazing alloy and HANDY FLUX. Heating is automatic gas-air; parts are placed on a rotating turntable to pass through the gas furnace. Every 60 working minutes, 650 assemblies are completed.

The advantages here are that the manufacturer can use thin-walled tubing with heavier, threaded components at no sacrifice in strength. Because of EASY-FLO's penetrating qualities, the entire shear area is fully as strong as the solid parts of the assembly, yet considerably lighter. And, casting and machining the components for this assembly have been greatly simplified.

Are you in pursuit of a metal-joining method which offers—among other advantages—high, uninterrupted production at low capital investment? You may easily find the answer in Handy & Harman silver brazing. Hundreds of manufacturers and fabricators of as many different products, parts and components are right now enjoying the speed, economy, strength and *flawlessness* of brazing. You can too. Just ask Handy & Harman, 82 Fulton Street, New York 38, N. Y.

FOR A GOOD START: BULLETIN 20

This informative booklet gives a good picture of silver brazing and its benefits... includes details on alloys, heating methods, joint design and production techniques. Write for your copy.

Your No. 1 Source of Supply and Authority on Brazing Alloys

HANDY & HARMAN

General Offices: 82 Fulton St., New York 38, N. Y.

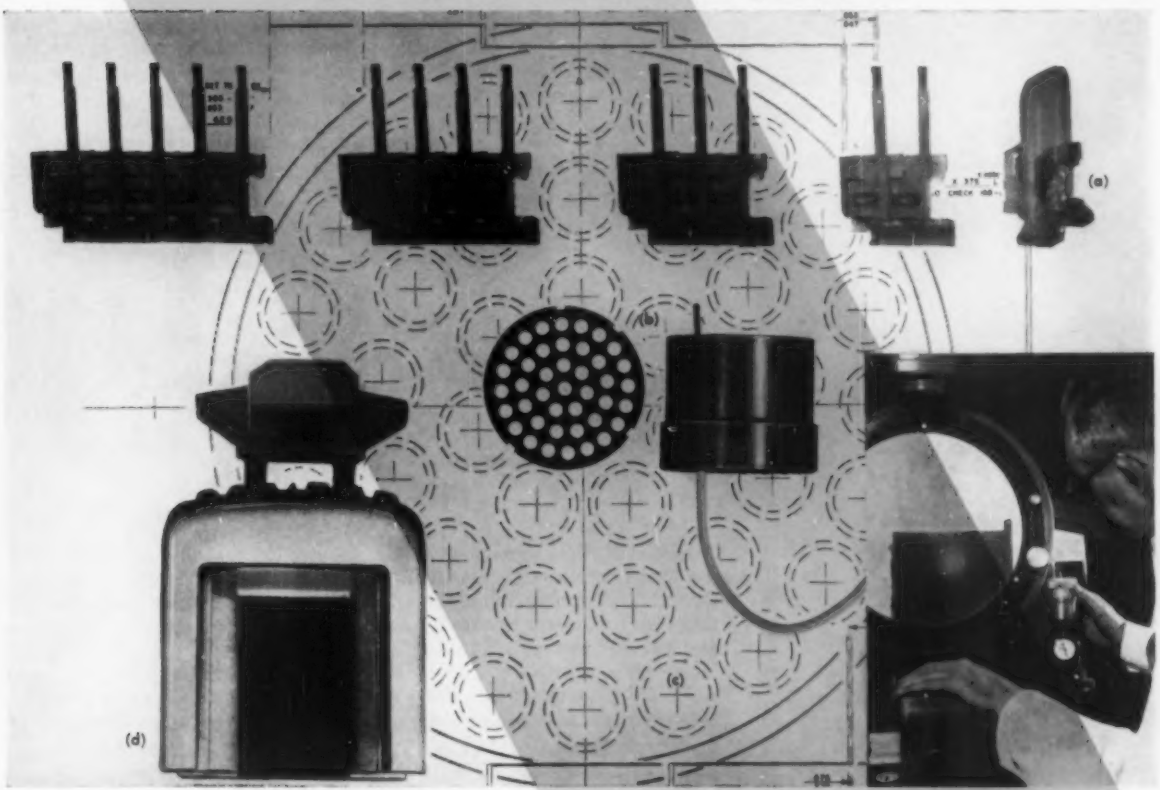
DISTRIBUTORS IN PRINCIPAL CITIES

Offices and Plants
Bridgeport, Conn.
Chicago, Ill.
Cleveland, Ohio
Dallas, Texas
Detroit, Mich.
Los Angeles, Calif.
New York, N. Y.
Providence, R. I.
San Francisco, Calif.
Montreal, Canada
Toronto, Canada

KEEP AHEAD WITH HAVEG

PRECISION PLASTIC MOLDINGS

"Haveg offers the most complete precision plastic molding facilities, experience and 'know-how' available anywhere."



(a) A series of crab locks molded from Nylon.
(b) Electrical connectors for making and breaking as many as 41 electrical circuits at one time are used in missile tracking equipment.
(c) Comparator chart in background enlarges connectors 10 times and checks the accuracy of all holes and insets.
(d) Pick-up head for stereophonic record player. This is a complicated but very small part (one third the width shown) in which three insets are molded into the head.

That's a strong statement but a very important one to remember in planning any type precision molding project. Haveg works with every known material to provide the most economical moldings . . . with properties necessary to meet the most rigid specifications.

Today Haveg is literally making design dreams come true . . . through its extensive research and development laboratory facilities as well as the best quality control laboratory within the industry.

Quality claims are made by many BUT Haveg and only Haveg provides the expert tool design and construction, equipment instrumentation, careful testing of incoming materials as well as many other specialized operations so necessary to assure highest quality precision moldings.

Haveg is justifiably proud of its unsurpassed versatility in facilities and engineering experience . . . we will be happy to put them at your disposal. Why not consult us on your next project . . . you'll find it pays to . . . keep ahead with Haveg.

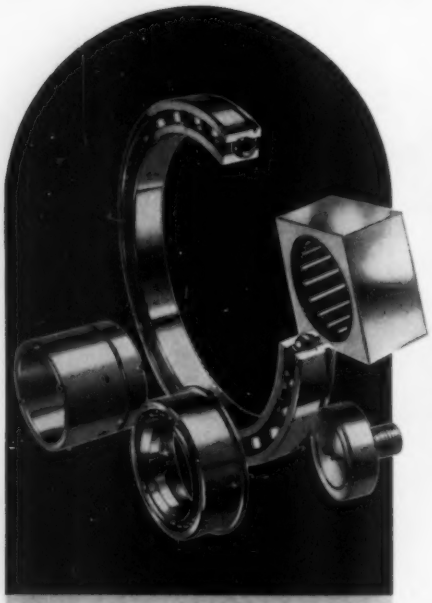
Keep Ahead with **HAVEG**

FIRST IN *Engineered* PLASTICS

TAUNTON DIVISION
HAVEG INDUSTRIES, INC.
336 Weir Street • Taunton, Massachusetts

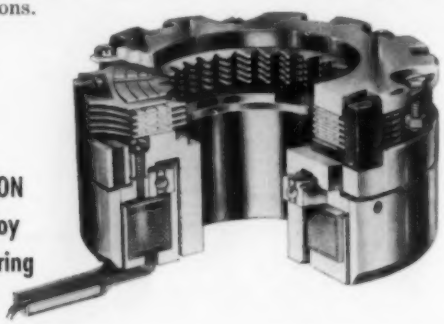
Other Operating Divisions: Blow Molding Division — Bridgeport, Connecticut • Chemical Materials Division — Wilmington, Delaware • Haveg Corporation — Wilmington, Delaware
Reinhold Engineering & Plastics Co., Inc. — Norwalk, California • American Super-Temperature Wires, Inc. — Burlington, Vermont • Hemisphere Products Corporation — Rio Piedras, Puerto Rico

CIRCLE 35 ON READER SERVICE CARD



McGILL® can solve your special purpose bearing problems

You may have found that a special bearing is the only way to add anti-friction advantages to non-standard shaft and housing dimensional combinations—perhaps a special type bearing incorporating odd shaped components or adjacent machine members will do the job best. Such special bearing design and production is part of everyday activity with McGILL. So don't design around a bearing barrier until you have consulted McGILL creative engineering. They will welcome an opportunity to make recommendations.

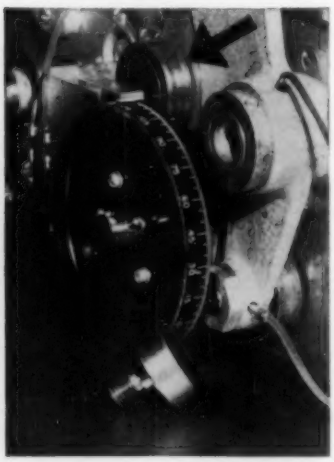


FAWICK AIRFLEX DIVISION magnetic clutches employ McGILL special ball bearing

A special McGILL precision ball bearing was developed to meet the exacting anti-friction requirements of the Fawick Stationary Field Magnetic Clutch. This extremely narrow and thin section bearing of comparatively large bore diameter is built to precision tolerances to accurately position and align all moving parts in relation to the stationary coil. Radial fit up is closely controlled to provide accuracy of magnetic flux air gaps. Retainer is nonmagnetic. Fawick relies on the McGILL bearing to facilitate the rapid and smooth response of the clutch even when operating at high cyclic rates.

McGILL bearings in record-breaking MERCURY outboard motors

Hydroplane speeds averaging over 107 miles per hour, runabout endurance runs of 50,000 miles in 68 days and outstanding power exhibitions by Mercury outboard motors are a true test of component performance. McGILL split center main bearing sleeves are used in 60-80 horsepower six cylinder Mercury outboard motors and have played an important part in the high standards of performance set by these motors.



CAMROL® bearings protect reliability of IBM accounting machines

McGILL CF Series CAMROL bearings improve performance and provide an additional safety factor for greater reliability in IBM 407 Accounting Machines. The CAMROL bearings are located on the card feed cam follower arms and they operate a pressure plate on the sensing unit of this high speed card feed. The IBM 407 Accounting Machine combines outstanding arithmetic ability and printing at a speed of 150 lines per minute.

engineered electrical products

McGILL®

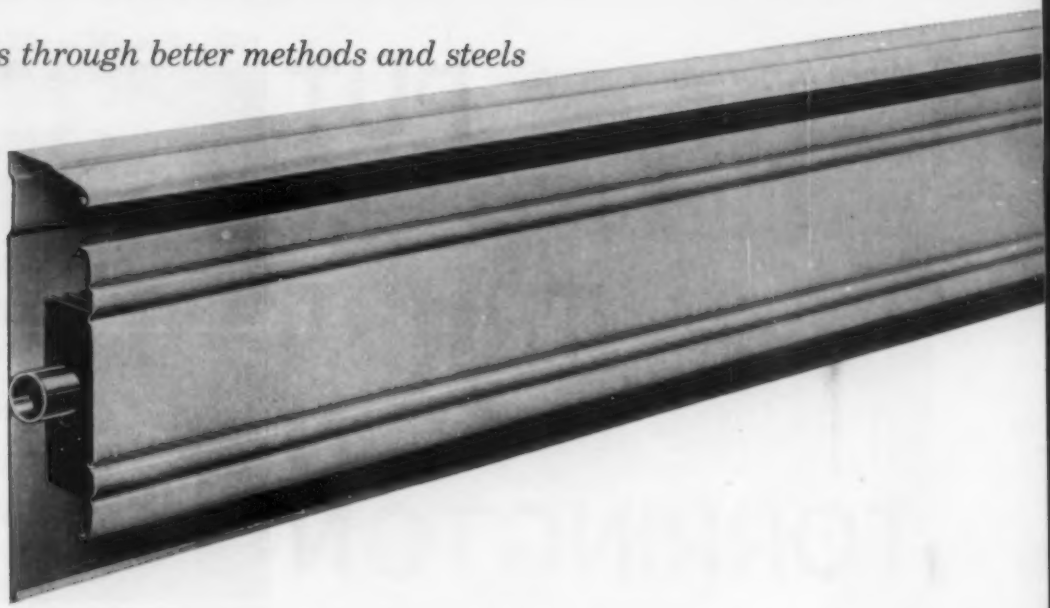
precision needle roller bearings

Send for free copy of McGill Bearing Catalog No. 52-A.

MULTIROL-GUIDEROL-CAMROL-CAGEROL

McGILL MANUFACTURING CO., INC., Bearing Division
201 N. Lafayette Street, Valparaiso, Indiana

Better products through better methods and steels



With Weirzin: easy fabrication of beautiful baseboard heating panels that last and last and last.

This high quality electrolytic zinc-coated and bonderized steel sheet is produced to our customers' requirements for uniformity of gage, width and temper. This attention to quality along with the excellent corrosion resistance provided by the zinc coating puts Weirzin at the top of its category and around the bottom of an increasingly large number of commercial and residential interiors.

There, these baseboard heating panels provide a functional border of beauty that requires little or no maintenance. The chemically treated surface holds the smoothest of paint jobs and the tight zinc steel bond eliminates all possibility of underfilm corrosion. Proof that despite the severe bending and forming it undergoes, Weirzin maintains a flawless bond between the zinc coating and the steel sheet.

Result? The fabricator enjoys the workability of a fine product and the ultimate consumer benefits from its serviceable beauty. And that's true of any product made from Weirzin.

Strong, smooth Weirzin electrolytic zinc-coated steel is manufactured by Weirton Steel Company. Its high quality is typical of the many other steels produced by Weirton and used throughout industry to improve products, methods and profits.

Steel

Look for the STEELMARK on the products you buy; place it on the products you sell.

WEIRTON STEEL
Weirton, West Virginia

WEIRTON STEEL COMPANY

Weirton Steel is a division of **NATIONAL STEEL CORPORATION**

When performance counts–

PUT YOUR TRUST IN TORRINGTON THRUST BEARINGS

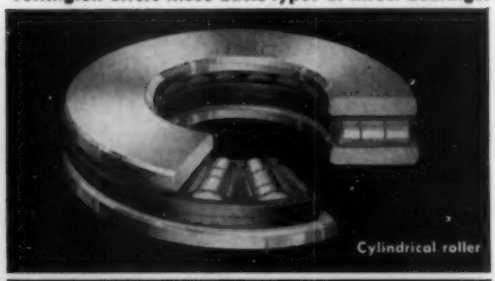
Whatever your performance requirements, there's a Torrington Thrust Bearing precision engineered to meet your needs.

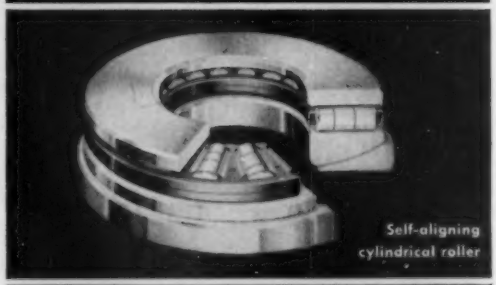
Cylindrical, self-aligning cylindrical, tapered . . . grooved race ball, angular contact ball or needle thrust —all are designed and manufactured to the highest Torrington standards for performance, reliability and long trouble-free service life.

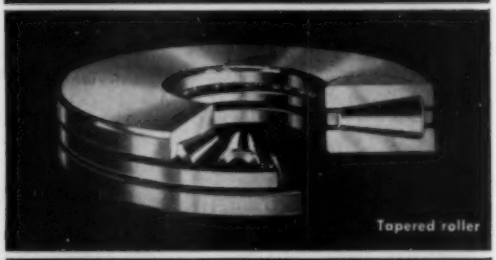
From the smallest to the largest—for power tools or giant radar installations—Torrington Thrust Bearings have the same unmatched precision quality built into every Torrington product. Depending on specific types and applications, they are available with a choice of bronze, steel or phenolic retainers.

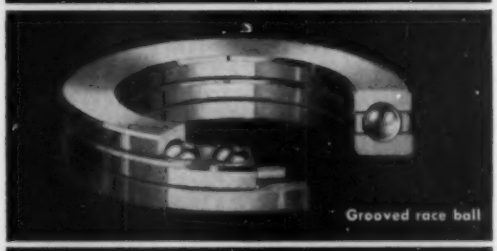
Whether your thrust application calls for a standard bearing or one specially designed to meet unique conditions, you can rely on Torrington for a bearing that's exactly right for the job. Contact Torrington—designers, engineers and manufacturers of every basic type of anti-friction bearing.

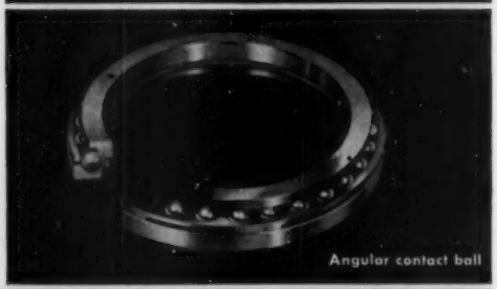
Torrington offers these basic types of thrust bearings.

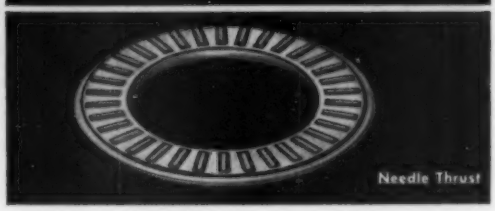

Cylindrical roller


Self-aligning cylindrical roller


Tapered roller


Grooved race ball


Angular contact ball


Needle Thrust

progress through precision

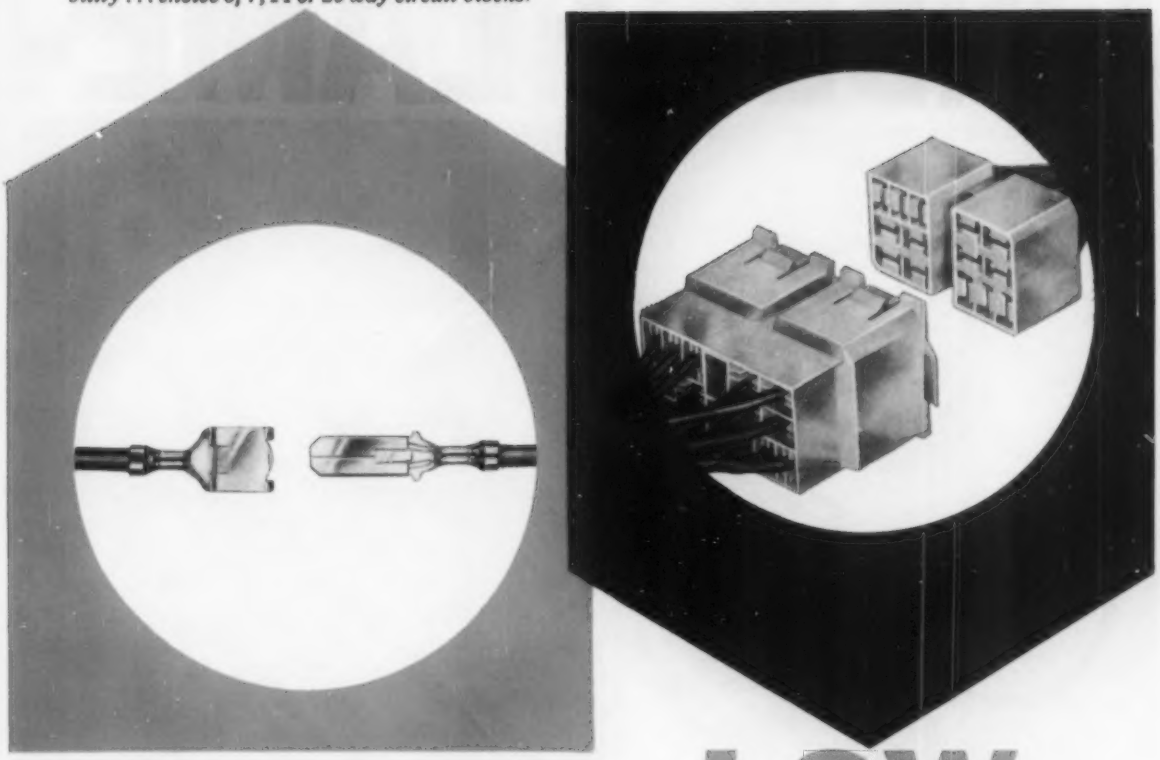
THE TORRINGTON COMPANY

TORRINGTON BEARINGS

South Bend 21, Indiana, Torrington, Conn.

HIGH

20-25 amperage rating for greater design flexibility . . . choice of 7, 14 or 20 way circuit blocks.



LOW

2-5 pounds insertion and extraction force for easier installation and servicing.

NEW AMPEEZ CONNECTOR GIVES YOU BOTH

Here is a workhorse of a connector! Housed in tough nylon and designed to carry as many as 20-circuits while holding insertion-extraction forces to 2-5 pounds, AMPEEZ Connectors are adaptable to many applications calling for a heavy-duty, easily serviced multiple-circuit disconnect.

AMPEEZ Connectors will match your application needs perfectly . . . anything you call for up to 20-circuits and 25 amps. One other major feature! *AMP's exclusive Tab-Gap Lok assures a constant contact pressure even under the severest vibration conditions.*

Use AMPEEZ Connectors, eliminate the human error in individual connections . . . make them fast and safe. Send today for AMPEEZ Connector literature and sample of tab and receptacle with Tab-Gap Lok.

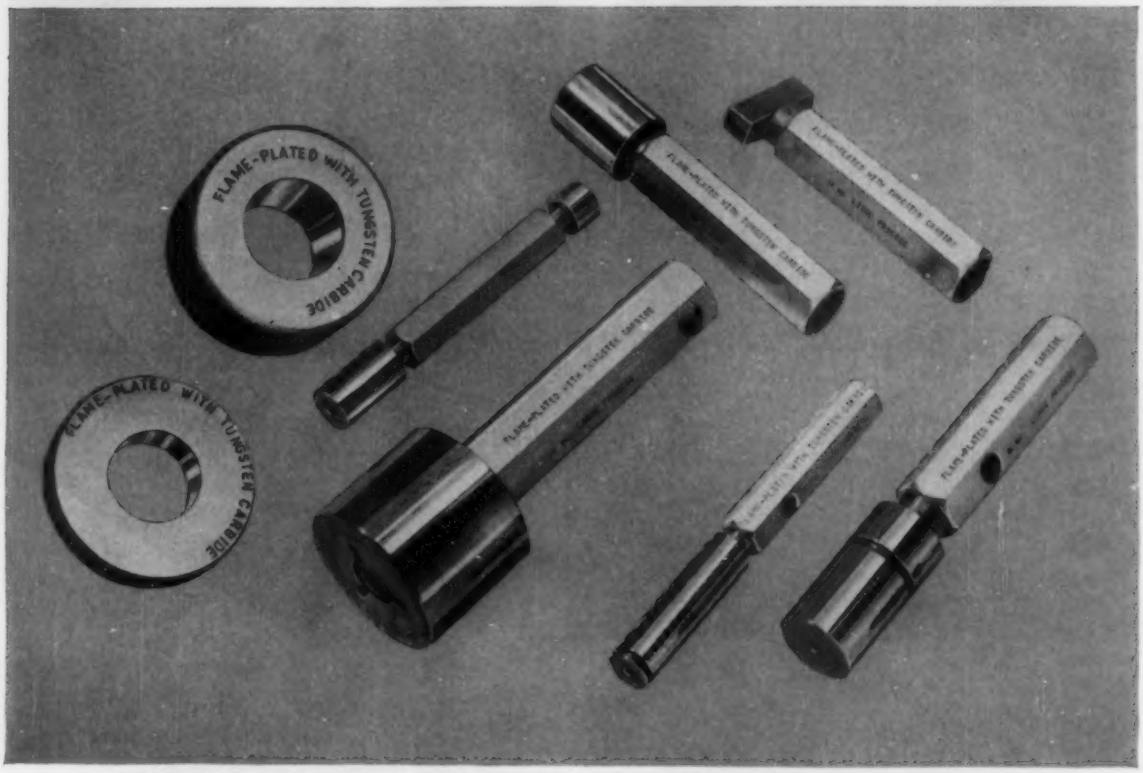
AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

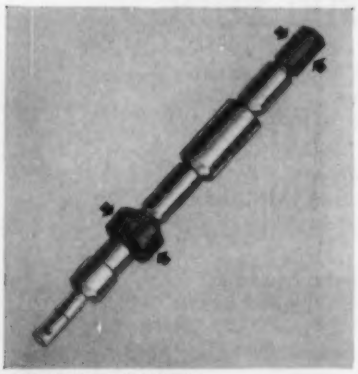
AMP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • West Germany

PRECISION PARTS GET TODAY'S

LINDE's FLAME-



GAGES—Superior wear resistance and other unique cost-saving advantages are exhibited by plug, ring, air, and specialty gages treated by LINDE's Flame-Plating. For example, Flame-Plated plug gages outwear solid carbide plug gages 3-to-1, and hard chrome-plated gages 20-to-1.

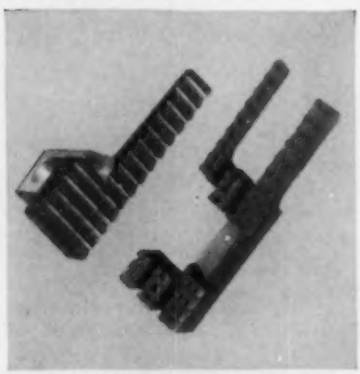


AIRCRAFT VALVES

Bearing surfaces of hot air valves used in the bleed air system of Lockheed's F-104A Starfighter must meet extreme conditions of wear and abrasion, also conditions of high unit loading and temperature extremes. Flame-Plating these surfaces with tungsten carbide solves the problem.

ALUMINUM ROCKER ARMS

One side of the "fin" of this important item in an aircraft engine heater mechanism actuates a lever and is subjected to severe wear. Before Flame-Plating, it lasted from 100 to 300 hours. Coating the wearing surface with tungsten carbide boosted service life to more than 1000 hours.



SEWING MACHINE FEED DOGS

LINDE's Flame-Plating has increased by more than six times the service life of the movable, serrated part that pushes material through the sewing machine. In this application, a .002-in. coating of tungsten carbide in as-coated condition provides both long wear and dependable gripping.

LONGEST SERVICE LIFE with PLATING

Gages and other components achieve remarkable resistance to wear when coated with tungsten carbide and other materials by LINDE's 6,000-degree, supersonic "weld-on" process . . .

NOW—many of the profit-consuming problems of metal wear and machine down-time have been eliminated.

With LINDE's Flame-Plating, gages, spindles, bushings, seals, mandrils, dies, core rods and other precision parts and components retain their precision and close tolerances for the *longest* period of time—under the toughest conditions of abrasion, erosion, corrosion, and high-temperature wear.

LINDE's exclusive service coats base metals with particles of ultra-hard materials, such as tungsten carbide and aluminum oxide—heated to plasticity by 6,000 degrees F. inside the Flame-Plating gun and then successively "fired" at 2,500 fps at the "target area."

The result is a tenacious, "welded-on" coating of approximately 125 microinches rms, which can be finished to the desired microinches rms.

NO WARPAGE—NO METALLURGICAL CHANGES

Despite the 6,000-degree temperature within the Flame-Plating gun, the temperature of the precision part or product being coated remains below 250 degrees F. This feature eliminates distortion and changes in the properties of base metals. Other features include low coefficient of friction and porosity of less than 1 per cent.

Wherever *continuing* precision and *optimum* wear are important factors, LINDE's revolutionary Flame-Plating gives amazingly longer service life . . . reduces production rejects . . . increases salvage value.

Find out how this coating service offered by the Linde Company can save on operating costs, make a good product even better, and improve over-all reliability. LINDE will provide a complete engineering analysis. List your possible applications in the coupon on the right and mail today for complete information.

TYPICAL FLAME-PLATING APPLICATIONS

BEARINGS—sleeve, roller, gas
BLADES—aircraft turbine; doctor blades for papermaking
BLOCKS—anvil
BUSHINGS—ball piston pump
CHUCKS—seaming
CUTLERY—household
CUTTING, INDUSTRIAL—rubber, plastic, skiving knives, foods, paper, slitter knives, chipper knives, discontinuous chip-abrasive materials
DIES, TOOLING—cold-forming; coring punches, core rods, sizing punches, capstans
DOGS—sewing machine feed; gripping dogs
DRILLS—paper, acoustical tile, twist
GAGES—plug, ring, air
GUIDES—wire, textile, machine
HYDRAULICS—pistons, liners, valve plates, wobble plates, metering valves, servo valves, slippers
MANDRILS—wire-forming
PARTS—sintered
PISTON RINGS
PLATES—valve, wear
SEALS—turbine engine, pump
SURGICAL—needle holders and shears
VALVES—aircraft

Linde Company, Flame-Plating PG-111
270 Park Avenue
New York 17, New York

I am interested in Flame-Plating for the following application(s):

_____

_____

_____

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE___ STATE____

LINDE COMPANY
Division of Union Carbide Corporation

UNION CARBIDE

LINDE and UNION CARBIDE are trade-marks of Union Carbide Corporation.

for a quality product

use a quality "O" ring

be safe with PRECISION!

Precision "O" Rings are engineered specifically for your product! They're made to do the job better... longer. They meet all military and commercial specifications. Precision "O" Ring quality is maintained by over 100 inspections and quality control tests. There's a size and compound to meet YOUR requirements. If it's Precision – it's Precision-made! Write, wire, or phone for data sheets or help of a Precision Sales Engineer today.

Precision Rubber Products Corporation

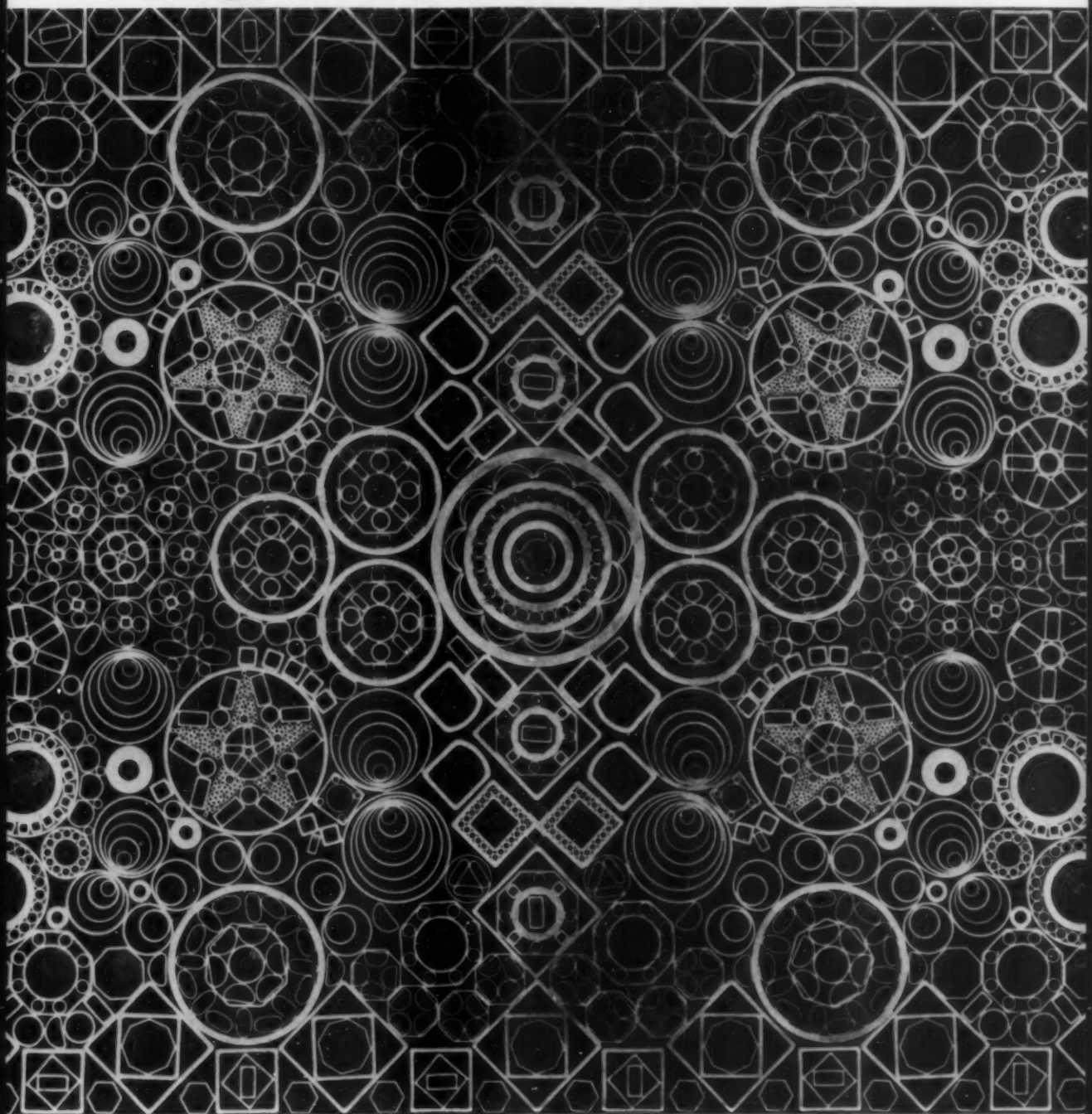
"O" Ring and Dyna-seal Specialists

Dept. 3, Oakridge Drive, Dayton 17, Ohio Canadian plant at: Ste. Thérése de Blainville, Québec

42 CIRCLE 42 ON READER SERVICE CARD

CIRCLE 43 ON READER SERVICE CARD →

This mark tells you a product is made of modern, dependable Steel.



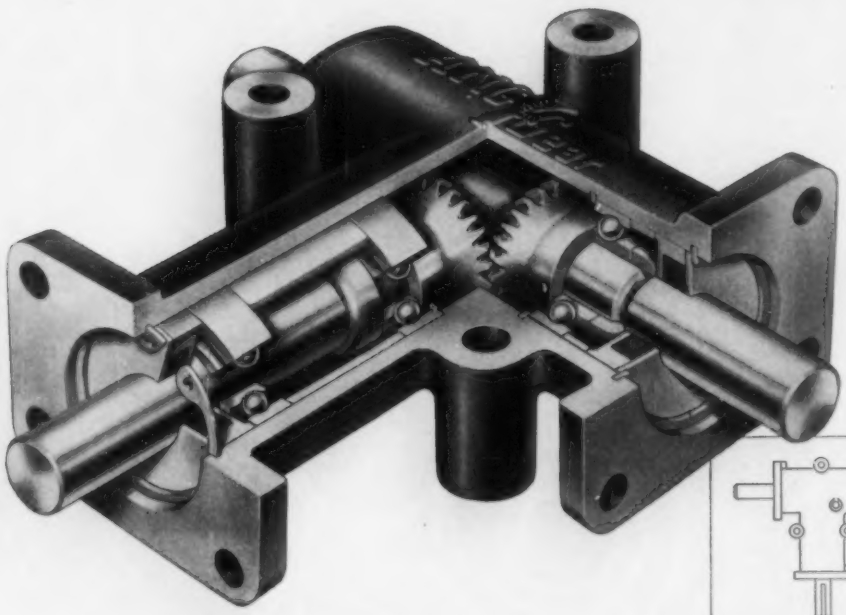
Seamless Steel Tubing comes in almost every shape and size, that is, if it's **USS National Seamless Mechanical Tubing.**

USS and National are registered trademarks

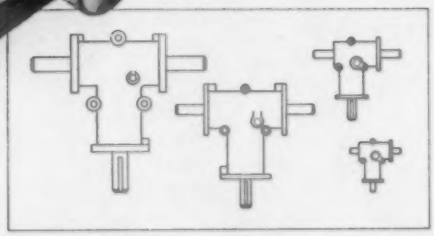
National Tube
Division of
United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors; United States Steel Supply Division; United States Steel Export Company, New York

There is only one ANGLgear®... and it is made only by Airborne



Quality of ANGLgear construction is evident in cutaway view. ANGLgear gives you all the features of other drives, plus greater hp range (⅛ to 5); permanent lubrication; and Coniflex* design gears for more even load distribution, reduced wear, quieter operation.



ANGLgear is available from local distributor stocks in 4 sizes, 16 models, with various gearing and shaft options.

ANGLgear – introduced in 1951– is the *original* standardized right-angle drive. It is also the No. 1 product in its field – in sales, availability, quality, performance. Witness the thousands of satisfied customers who have bought ANGLgear to date – for applications ranging from simple manual control of valves to classified installations aboard nuclear submarines.

In design and construction, ANGLgear has been refined to the point of being virtually foolproof, provided it is not grossly overloaded. Take a unit off the shelf, install it, run it–for years. And attention is seldom required.

Besides being maintenance-free, ANGLgear is also easy to design into your power transmission systems because of its universal mounting feature. And it invariably costs less than other types of drives. ANGLgear is distributed nationally and is available immediately from local distributor stocks in the models listed here. Special sizes, special gear ratios, etc., can also be furnished. For complete engineering data, contact our local distributor, or write direct for new Catalog IA-58. *ANGLgear design template kits are available on request.*

*Trademark of the Gleason Works

BASIC MODEL DATA

Model	Type	Gear Ratio	HP	RPM Output Shaft	Ultimate Static Torque lb. in. Output Shaft	Shaft Dia.	Wt., lb.
R-300	2-way	1:1	1/3	1800	250	3/8	.5
R-300-2	2-way	2:1	1/5	1800	250	3/8	.5
R-310	3-way	1:1	1/3	1800	250	3/8	.5
R-310-2	3-way	2:1	1/5	1800	250	3/8	.5
R-320	2-way	1:1	1	1800	1000	5/8	2.2
R-320-2	2-way	2:1	3/5	1800	1000	5/8	2.2
R-330	3-way	1:1	1	1800	1000	5/8	2.4
R-330-2	3-way	2:1	3/5	1800	1000	5/8	2.4
R-333	2-way	1:1	2-1/4	1200	1500	3/4	8.7
R-333-2	2-way	2:1	2-1/4	1200	1500	3/4	8.7
R-335	3-way	1:1	2-1/4	1200	1500	3/4	9.0
R-335-2	3-way	2:1	2-1/4	1200	1500	3/4	9.0
R-340	2-way	1:1	5	1200	2500	1	14.5
R-340-2	2-way	2:1	5	1200	2500	1	14.5
R-350	3-way	1:1	5	1200	2500	1	15
R-350-2	3-way	2:1	5	1200	2500	1	15

AIRBORNE®

Engineered Equipment for Aircraft and Industry

AIRBORNE ACCESSORIES CORPORATION

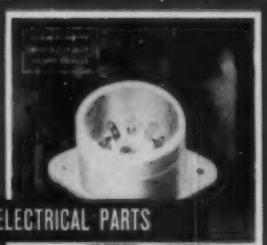
HILLSIDE 5, NEW JERSEY

HIGH DENSITY
POLYETHYLENE
PROFIT PARADE

TOYS

INFANTS' FURNITURE

TAKE A LOOK AT THE WHOLE PICTURE



ELECTRICAL PARTS

APPLIANCES

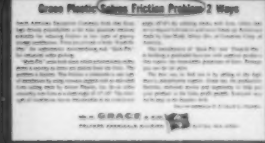
HOUSEWARES

These plastic products share one point in common

PACKAGING PRODUCTS

INDUSTRIAL COMPONENTS

MATERIALS HANDLING EQUIPMENT

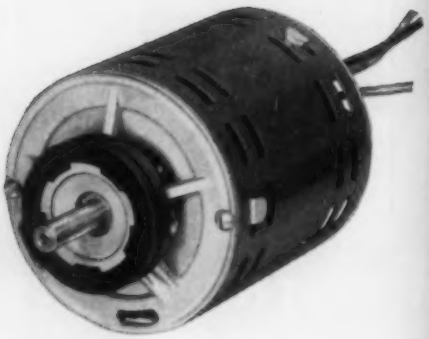


These products offer concrete evidence of manufacturers who have realized the profit-making opportunities to be found in high density polyethylene from W. R. Grace & Co. New products . . . better products . . . products that last longer . . . cost less to make . . . products with greater sales appeal . . . products that complete a product line—all can start with Grex High Density Polyethylene. If you have an application for high density polyethylene—or think you have—it will pay you to call Grace.

Grex is the trademark for W. R. Grace & Co.'s Polyolefins.

W.R. GRACE & CO.
POLYMER CHEMICALS DIVISION
CLIFTON, NEW JERSEY

CIRCLE 45 ON READER SERVICE CARD



this R & M motor puts the "Drive" in IBM electric typewriters!

Almost twelve years have elapsed since International Business Machines Corporation used its first R&M motor to power its electric typewriters. Since then R&M has supplied thousands upon thousands of these special motors for IBM's world-wide typewriter trade. In order to meet varying electrical conditions the world over, they are now supplied in 21 different voltages and frequencies.

IBM proposed strict requirements for powering their machine. The motor must have high starting torque for quick response . . . run very quietly . . . cooler than normal . . . fit a limited space . . . and have stamina to perform dependably year after year. Within a short period of time, R&M delivered specifications for the right design—a dynamically balanced motor that fulfilled all of IBM's standards, including reliable operation that covers thousands of hours between check-ups.

A lot of fingers have gone over the keys since R&M produced its first IBM typewriter motor, but we still subject each IBM power unit to 100% inspection. Moreover, we constantly work with IBM—and all our customers—to improve our motors and to adapt them to the ever-changing requirements of customers' products.

R&M's experience in custom-designing motors for hundreds of products, and our facilities to produce a design at low cost, are at your service. Perhaps your problem can be met with a standard *"off-the-shelf"* power unit. If so, we'll tell you . . . and recommend the right R&M motor for the job. For power by either custom or standard fractional HP motors . . . and performance that will give you a big competitive advantage . . . get in touch with Robbins & Myers today! Write for Bulletin No. 450-PRE

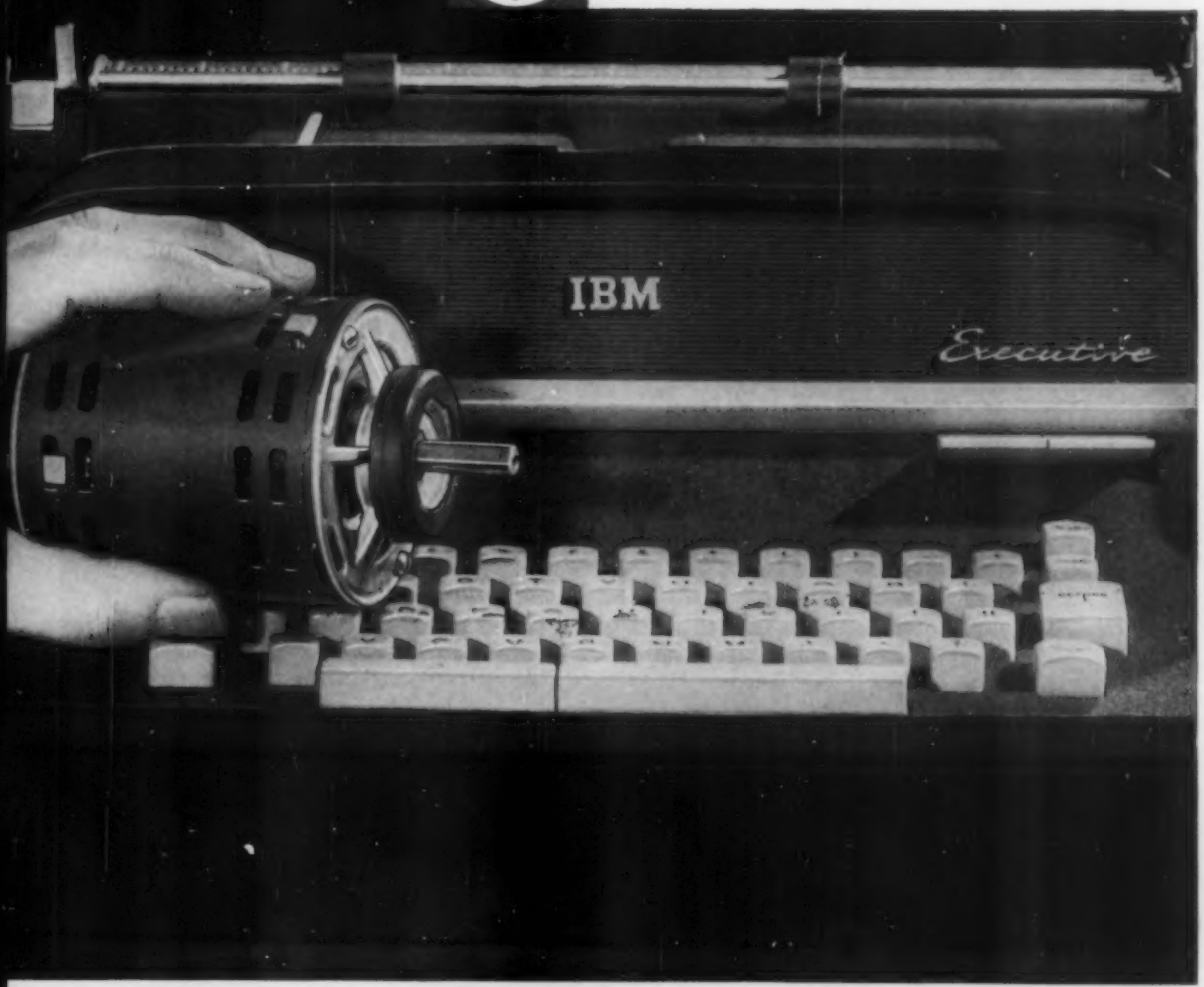
ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO • BRANTFORD, ONTARIO

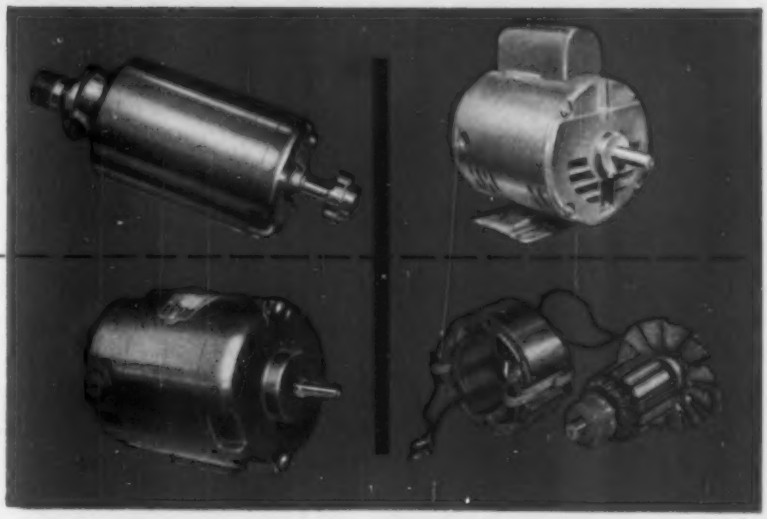
MOTORS 1/200 thru 1 HP

(other ratings up to 200 horsepower)



At left, Retractable Capstan Motor . . . shaft of this special R&M fractional HP motor rotates and also moves axially. Manufactured for IBM's 727 Magnetic Tape Unit.

At right, Standard Fractional HP Motors . . . a wide range of types, sizes and mountings for DC, single or polyphase AC; all standard voltages and frequencies.



At left, Standard Universal Motors . . . ratings from 1/50 to ½ HP. Choice of end, pad or foot mountings to permit design versatility. Custom designs also available.

At right, Series Motor Parts . . . precision-made series, universal or polyphase high-cycle motor parts. All types and sizes engineered to your requirements.

CIRCLE 47 ON READER SERVICE CARD

size is no problem!

The bigger your tubular steel problem – the better we like it! Why? Because with all our modern facilities "under one roof," we are completely equipped to handle a variety of difficult jobs – expertly and economically! For expert consultation on centrifugally spun tube applications in your field... call on ACIPCO.

VERSATILE ACIPCO CENTRIFUGALLY SPUN STEEL TUBES

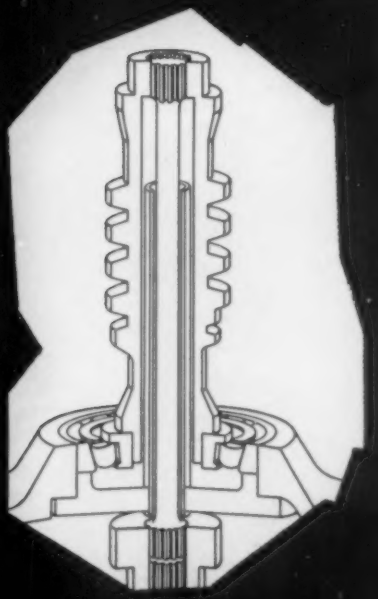
SIZE RANGES: Tubes are produced in lengths from 4′ to 20′; longer lengths are made by welding. O.D.'s from 2.25″ to 50″ — wall thicknesses from .25″ to 8″.

ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steels, plain carbon steel and special non-standard analyses.

FINISHES: As cast, rough machined, or finish machined, including honing and grinding. Complete welding and machine shop facilities are available.

Write for FREE Illustrated Catalog.

ACIPCO
SPECIAL PRODUCTS
DIVISION OF AMERICAN CAST IRON PIPE CO.
BIRMINGHAM • ALABAMA



The NEW Westinghouse Verti-Seal Floating Gearmotor

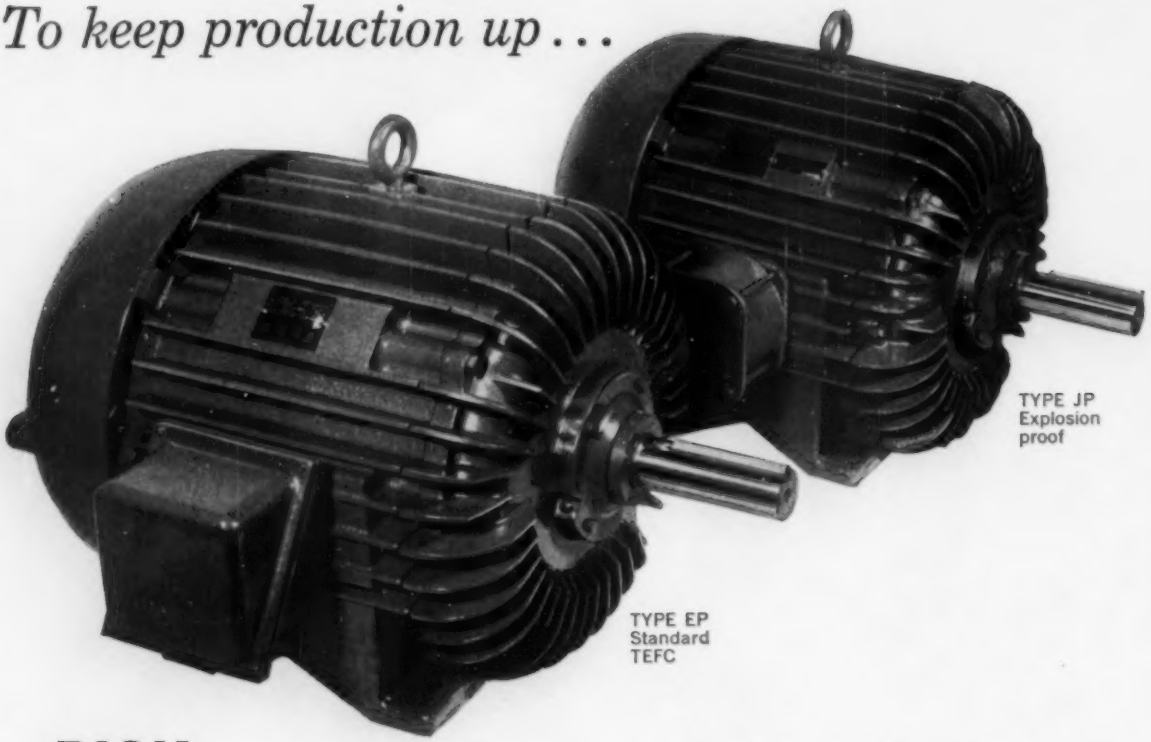
Right-Angle Gearing at Work

Verti-Seal gearmotors use a special seal which prevents the lubricating oil in the gear casing from leaking into the motor windings. All wearing and brittle parts of conventional seals have been eliminated, bringing *leakproof* operation to gearmotors for roll table and heavy-duty conveyor applications . . . Ask your Mr. Westinghouse for a copy of our new four-page booklet on floating gearmotors (B-7998) or write: Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pa. *You can be sure . . . if it's Westinghouse.*

J-21166

Westinghouse

To keep production up . . .



PICK FROM THIS PROTECTED PAIR...

Here's a power-packed pair of Wagner® totally-enclosed fan-cooled motors —Type EP, standard, protected against damage from dust, abrasive, fumes, steel chips or filings; and Type JP, explosion-proof, for safe use in specified hazardous locations.

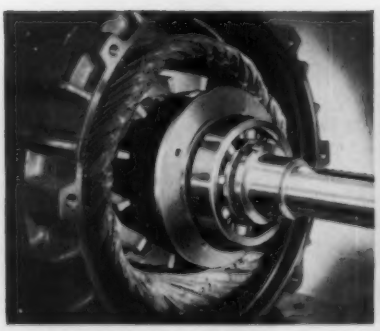
They'll keep your production rates up, delivering full rated horsepower under the toughest conditions . . . staying on the job with dependable, continuous service that means peak output. They're the perfect pick, for individual machines or for automated lines.

In the design illustrated, these motors are built in ratings through 100 hp in NEMA frame sizes 182-445U. Let your Wagner Sales Engineer show you how this protected pair (or larger Wagner enclosed motors through 500 hp) gets the job done. Call him, or write us for Bulletin MU-224.

Wagner Electric Corporation

6406 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI

WM60-19

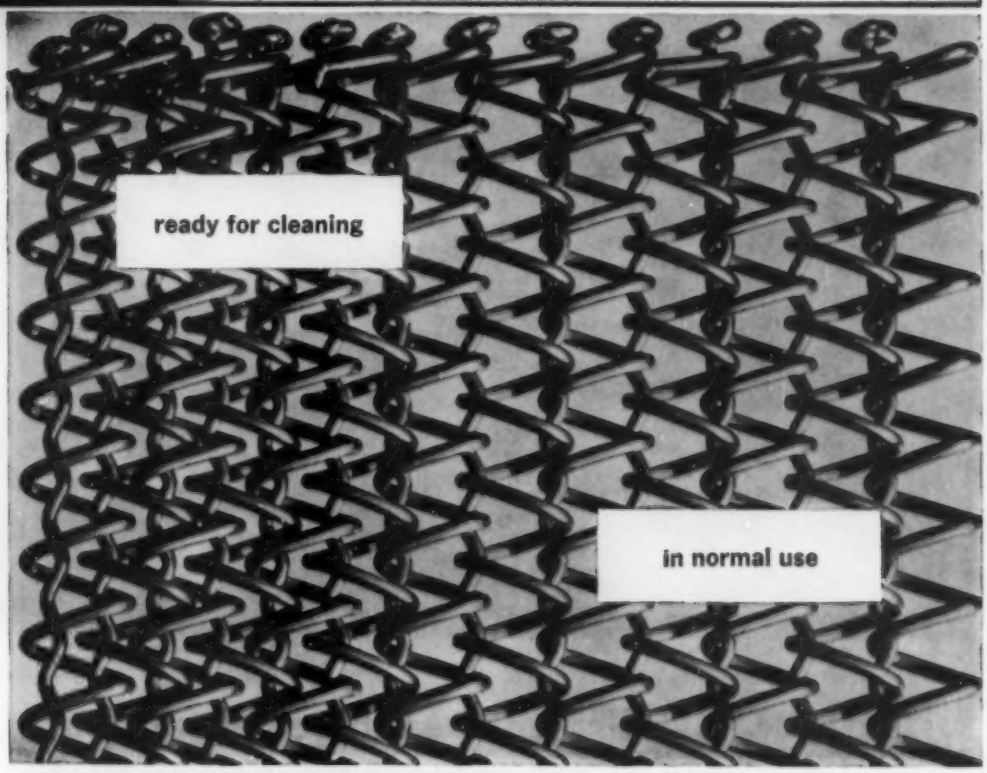


HEAVY-DUTY BALL BEARINGS . . . The ball bearings used in these motors are of the highest quality, with more than ample capacity to provide long, troublefree service under heavy loads.

BEARINGS CAN BE RELUBRICATED . . . Factory lubrication will last for many years under normal service, but openings are provided to permit relubrication that adds years to motor life under severe conditions.

SECURELY SEALED FOR LOW MAINTENANCE . . . Both ends of these motors have running shaft seals to keep the bearings clean. Bearing housings are effectively sealed to prevent escape of grease.

new Cambridge COLLAPSIBLE METAL-MESH CONVEYOR BELT* GIVES INSTANT SANITIZING



WHERE CAN YOU IMPROVE OPERATIONS WITH THIS UNIQUE BELT?

The new Cambridge Collapsible metal-mesh conveyor Belt is designed so that each component part separates completely when the belt is slackened, allowing bacteria producing particles, oils, greases or other foreign matter to be easily and quickly flushed away. Originally designed for the food industry, this new belt is now helping processors meet rigid sanitation requirements, improve product quality and cut maintenance and down time.

Perhaps the Collapsible Belt can be used in the equipment you are designing—for instance, to prevent contamination of chemicals or man-made products, or any application where quick, thorough cleaning of the processing belt is desirable.

The Cambridge Collapsible Belt is available in any length or width in the Balanced Weave, woven from any metal or alloy, including stainless steel. Get the full story today. Contact your Cambridge Field Engineer or use the coupon to get complete details.

**Patents Pending*

CAMBRIDGE WIRE CLOTH CO.
Department P, Cambridge 11, Maryland

Please rush me information on the new Cambridge Collapsible Belt.

_____
(Application—please indicate)

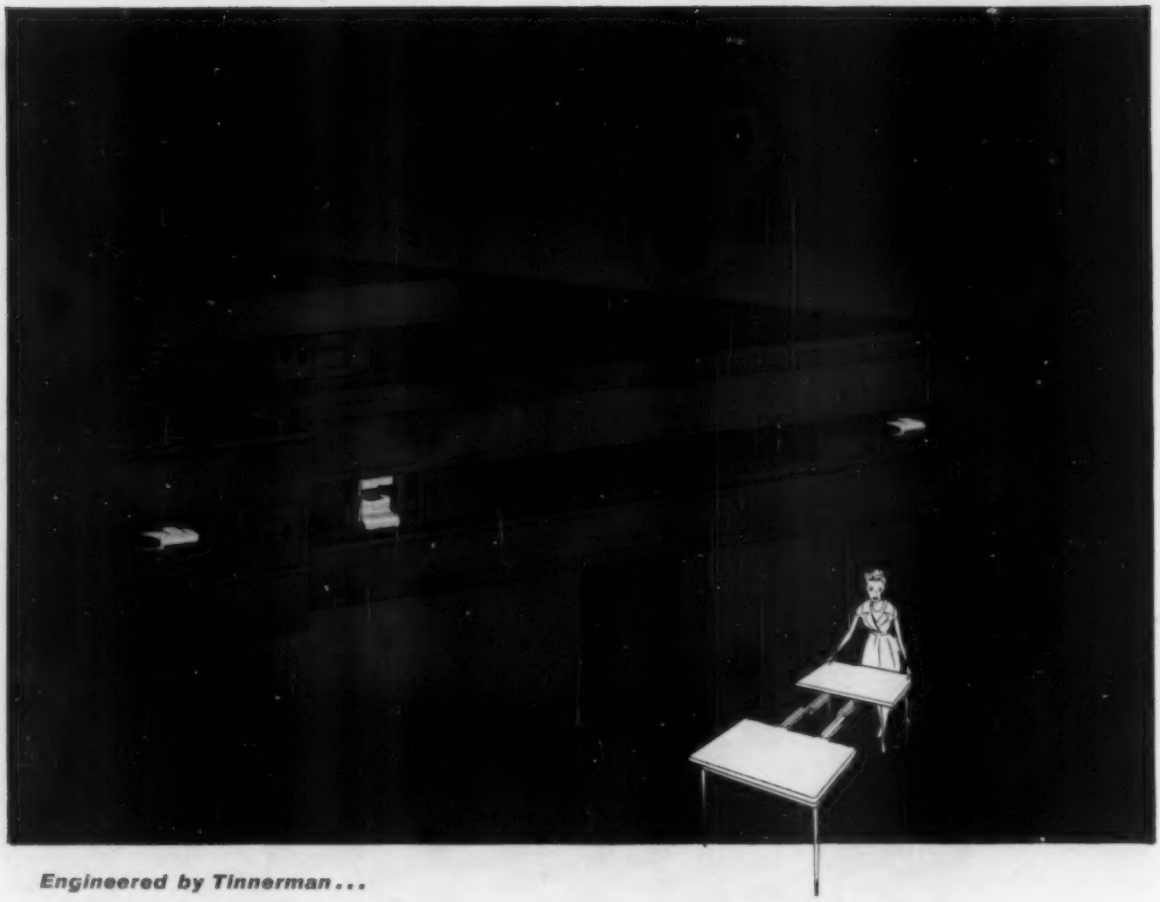
Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

CIRCLE 51 ON READER SERVICE CARD 51



Engineered by Tinnerman...

SPEED CLIP® replaces three parts on table-slide ...rate of assembly increased by 50%!

New all-steel nonbinding slides made by Watertown Table-Slide Company are now assembled faster, better! One Tinnerman SPEED CLIP replaces three separate parts used in earlier designs and produces double-header savings for Watertown.

This special spring steel SPEED CLIP holds the slides together firmly, yet lets them slide easily without binding. One quick stroke with an ordinary mallet seats and locks the SPEED CLIP in place. Long service life without loosening or sagging is assured.

Savings and assembly advantages like these are possible on your product too. Call in your Tinnerman representative and let him show you how. He can acquaint you with the 10,000 variations of SPEED NUT Brand Fasteners bringing similar benefits to manufacturers everywhere. He can also arrange for a FASTENING ANALYSIS of your product. This no-charge service has saved industry millions of dollars. Why not see what it can do for you? Tell us when you would like to have him call.

TINNERMAN PRODUCTS, INC.
Dept. 12 • P.O. Box 6688 • Cleveland 1, Ohio

TINNERMAN
Speed Nuts®

FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Hocano-Bundy GmbH, Heidelberg.

the mark of Cain

Just where does a man's moral responsibility for another's safety stop? There are laws that spell out the limits for industry, but at home or on the highway every man is his own master. He can buy—and injure or kill himself with any mechanism he wishes to use—a gun, a power tool, a motive-powered vehicle. He takes his own chances, in perfect freedom, even if it is the design that is at fault.

"And it came to pass, when they were in the field, that Cain rose up against Abel his brother, and slew him."

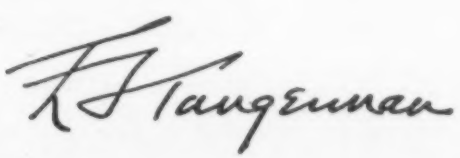
Every mortgagee with a 40-ft-square plot of grass buys a power mower. Statistics indicate that 12,000 injuries were caused by power mowers last year; this year's figure will be up 15%. But it is proudly said "only 8% of the accidents were caused by faulty design."

And the Lord said unto Cain, "Where is Abel thy brother?" And he said, "I know not: Am I my brother's keeper?"

Statistics indicate that each year autos kill more people than we lost in the Korean "police action." We're much concerned about war. But doors on cars still pop open at the slightest crash, the steering shaft and visors are still hazards to the driver, as the "eyelids" and other excrescences on the car front endanger pedestrians. And brakes have not been redesigned to match the higher speeds and heavier weights they must counteract. Coupled with the man-on-horseback recklessness of the present-day driver, our cars are Juggernauts.

Cornell and other colleges have pointed the way to safer designs, the National Safety Council has collected shocking statistics and data. Ford even made tentative design changes and based a sales program on safety. . . . It didn't sell. There are no laws as stringent as those covering aircraft design, so why worry? The buyer may take his own chances, as may the pedestrian. That's freedom. . .

And He said, "What hast thou done? the voice of thy brother's blood crieth unto me from the ground:" . . . And the Lord set a mark upon Cain.



THINK POLYESTER RESINS! THINK LAMINAC® THE PIONEER POLYESTER!

■ Ease of fabrication in unusual shapes ■ Corrosion-resistance ■ High strength with low weight ■ Excellent electrical properties ■ Low tooling costs ■ Below are just a few of the 22 standard formulations of Laminac® Polyester Resins. Reinforced plastics with Laminac have been replacing wood and steel in countless areas since 1942 – when American Cyanamid pioneered the reinforced plastics field. Whatever *your* needs, there is a formulation of versatile Laminac specially compounded to solve your problems. For more information, write us today.

FITS ANY ENGINEER'S SPECIFICATIONS

LAMINAC 4107. Outstanding chemical-resistant resin; high reactivity; suitable for compression molding; especially suited for chemical tanks, exhaust systems and other equipment.

LAMINAC 4103. Medium reactive resilient resin for craze-free moldings; ideal for molded parts required to withstand heavy mechanical abuse, such as auto bodies, carrying cases.

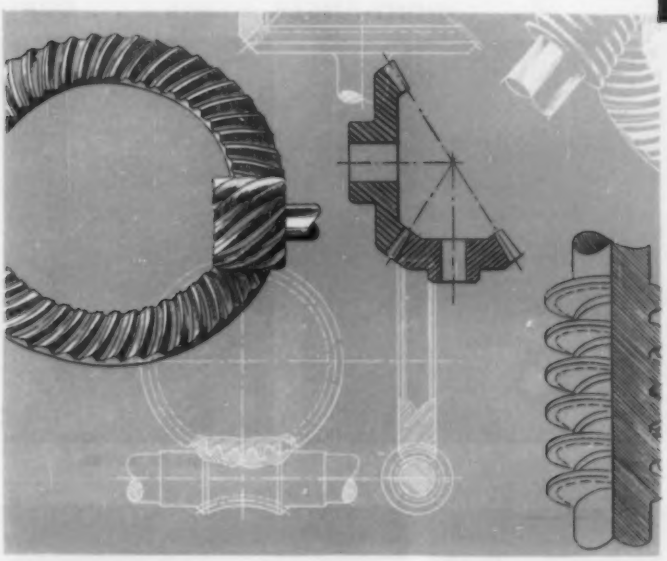
LAMINAC 4152. An outstanding resin for spray gun applications; rapid cure; unexcelled strength properties in laminates with chopped glass fibers; for use in boats, swimming pools, other large structures.

LAMINAC 4128. Highly reactive, heat-resistant resin for hand lay-up or compression molding; exceptional strength in laminates; qualified for military specification MIL-R-7575A; ideal for glass preform binders; for ducts, fuel tanks, storage tanks, aircraft parts.

CYANAMID

AMERICAN CYANAMID COMPANY
PLASTICS AND RESINS DIVISION

South Cherry Street, Wallingford, Conn. OFFICES IN: BOSTON • CHARLOTTE • CHICAGO • CINCINNATI • CLEVELAND • DALLAS • DETROIT • LOS ANGELES MINNEAPOLIS • NEW YORK • OAKLAND • PHILADELPHIA • ST. LOUIS • SEATTLE • IN CANADA: CYANAMID OF CANADA LIMITED, MONTREAL • TORONTO



WHICH RIGHT-ANGLE GEAR SYSTEM?

Your guide to the 16 types that are now available. The authors discuss basic differences, then compare on the basis of power, efficiency, speed, ratio range and mounting sensitivity—to help you choose the best gear system for your application.

ABOUT THE AUTHORS

Darle Dudley, well known for his book *Practical Gear Design*, published by McGraw-Hill, is editor-in-chief of the forthcoming McGraw-Hill *Gear Handbook* which brings together contributions from numerous sources in the gear industry. He is chairman of the AGMA Aerospace Gearing Committee, and recently received the Edward P Connell award "in recognition for his many and valuable contributions to the work of AGMA, of his service to the gear industry, and as an authoritative author of gearing literature."

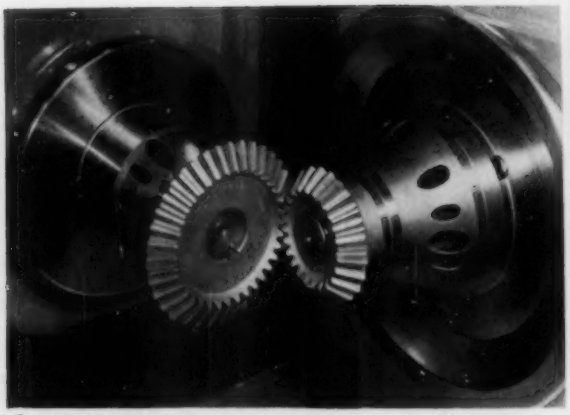
Dick Bryant, a cum laude graduate from Tufts University, has done design appraisals on projects such as VTOL, STOL, helicopter, rocket and special amphibious-vehicle transmission systems. Several of these projects involve the selection of right-angle gearing. Before joining GE, he worked with General Motor's research staff on lubrication and wear problems.

RICHARD C BRYANT *engineer, Aircraft and Missile Gearing*
DARLE W DUDLEY, *manager, Advance Gear Engineering*
General Electric Co, Lynn, Mass

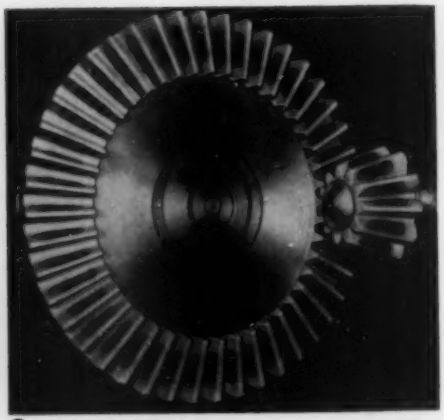
There are 16 separate and distinct types of right-angle gear drives, each with its own advantages and limitations. This means that choice of the best type for a given job involves many considerations. What is optimum for one application most likely will not be optimum for another. For example, hypoid gearing is the almost universal choice for automotive rear-end drives because offset of the pinion centerline allows a low floor in the car. Also these gears are quiet, efficient, and can carry large amounts of power. But hypoid would not necessarily be the wisest choice for a hand-operated drill where it would be difficult to control the locating dimensions of the gears, and where capacity and efficiency are not so important.

This article compares the 16 systems on the basis of power, efficiency, speed, ratio range, and mounting

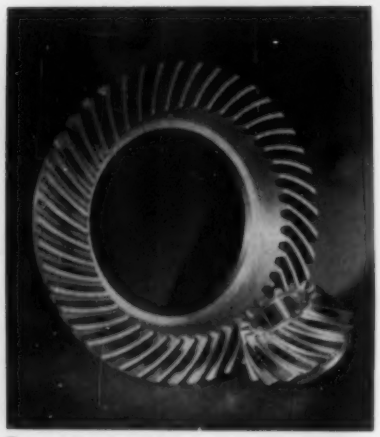
Copyright 1960 by the McGraw-Hill Publishing Co Inc



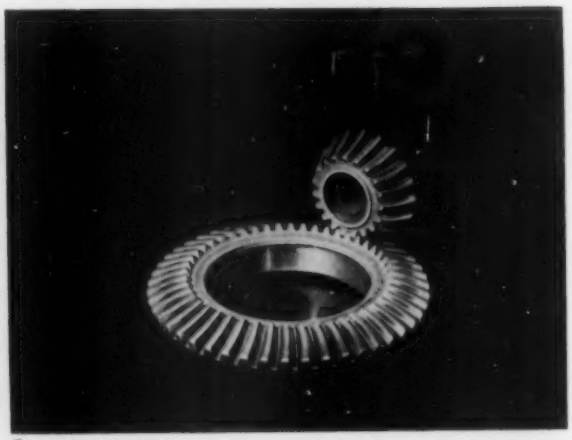
1 STRAIGHT BEVEL



2 CONIFLEX BEVEL



3 SPIRAL BEVEL



4 ZEROL BEVEL

sensitivity, and gives charts and tables on efficiency, horsepower ratings, manufacturing methods.

A LOOK AT THE RIGHT-ANGLE SYSTEMS

Two general classifications cover the right-angle gears:

Coplanar types, which have intersecting axes. In this category are the bevel-gear systems—straight bevel, Coniflex bevel, Zerol bevel, spiral-bevel and Revacycle bevel. Two other systems with intersecting axes are face and Beveloid gears (names capitalized indicate proprietary gear systems).

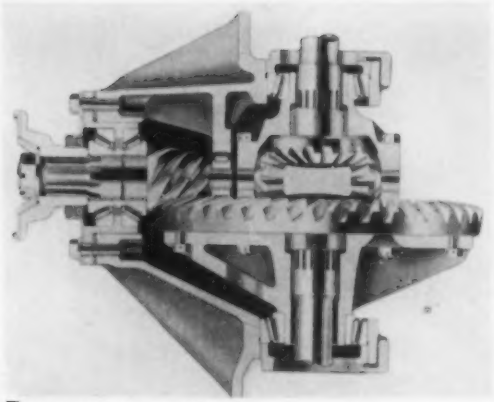
Offset types, which have nonintersecting or skew axes (their axes do not lie in a common plane). In this category are the crossed-helical, cylindrical-worm, Cone-Drive, hypoid, Spiroid, Planoid and Helicon. With proper design, face and Beveloid gears can also be employed as offset gears.

Each gear system is distinctive in the kind of manufacturing equipment required to make it and selection will depend on efficiency characteristics, mounting requirements, load-carrying capacity and availability of manufacturing facilities. The tooth form employed is not important in itself from the standpoint of mathematical theory. Here's a brief description of each right-angle gear system:

Straight-bevel gears

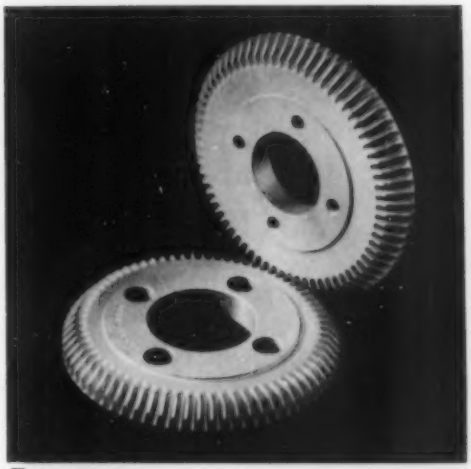
The blanks are conical for both members. Tooth form approximates an involute in the normal section. The teeth taper. The cutting tool represents a crown rack having straight teeth.

These gears are the simplest and most commonly used form of bevel gearing. The machines to generate them, and more recently to grind them, were developed by the Gleason Works, Rochester, NY. More recent Gleason introductions are the Coniflex and the Revacycle bevel gears. Both are straight-bevel type with localized tooth contact produced by slightly relieving the ends of the teeth. They have the advantage of better ability to withstand small gear-mounting errors, or deflections under load, without unduly overloading the ends of the teeth (which may result in breakage). All straight-bevel gears produced on recent Gleason machines are Coniflex. Revacycle gears are made on



5 REVACYCLE BEVEL

6 FACE GEARS



7 BEVELOID

special machines and are mostly for large-quantity applications, such as for automotive differentials.

Spiral bevels, Zerol bevels, hypoids

These gears are cut on conical blanks. Teeth of both members are tapered. The cutting tool represents a crown rack having a curved tooth. Spiral-bevel teeth have a slope like helical gears. Zerol teeth are curved with a zero slope at midpoint of the face width. Hypoid gears have the axes offset—otherwise they are similar to spiral-bevel gears.

Generally, the gear member of the pair is made first and the pinion member is then cut to match. The tooth form in the normal section approaches that of an involute.

Spiral-bevel gears have smoother, quieter action than straight bevels because the teeth have a lengthwise curvature and are cut at an angle to the gear axis.

Zerol-bevel gears avoid the overlapping tooth action of spiral-bevel gears because of the zero spiral angle. This also eliminates some of the thrust reaction on the mounting bearing. Bearing reactions do not depend on direction of rotation and the gears can be mounted interchangeably in the same mounting structure used to support straight-bevel gears.

Hypoid gears grew out of the automobile industry's need for a silent rear-end drive which would allow the driveshaft to be below the centerline of the rear axle. Special high-ratio hypoid gears are available for ratios above 10:1. These offer the advantage that both members can be ground, providing maximum accuracy.

Face gears

Here the pinion is a normal involute-toothed part. The gear has teeth cut on the end face of the blank by a cutting tool that is an exact duplicate of the pinion.

Face gears can be designed to mesh either "on center" (axis of the pinion lies in the same plane as the axis of the gear) or "off center" (pinion axis is offset, much as a hypoid pinion is offset). Because the pinion of the face-gear set is simply a spur gear, it can be produced by any of the standard spur-gear methods such as hobbing, shaping, or grinding. Also, the axial location of the pinion is not critical, which simplifies mounting. Face gears were developed by the Fellows Gear Shaper Co, Springfield, Vt.

Beveloid gears

Beveloid gears are basically involute gears with tapered tooth thickness, root and outside diameters. The appearance is much like a straight-bevel gear, but every transverse section represents a spur gear. This means that a Beveloid gear will mesh properly with any other involute gear derived from the same basic rack.

In right-angle gear systems, the Beveloid gear offers four major advantages:

1—Mounting dimensions are not critical.

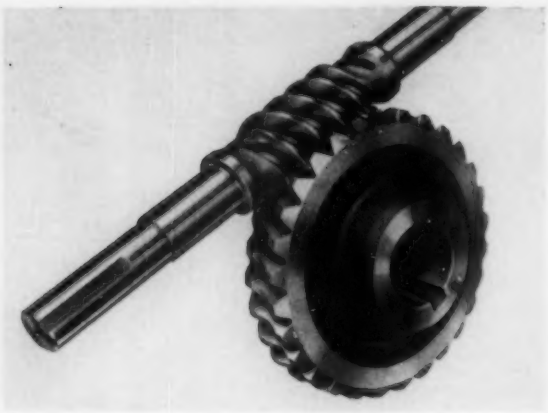
2—The two gears do not require a common vertex.

3—Beveloid gears are individually interchangeable, without lapping or matching.

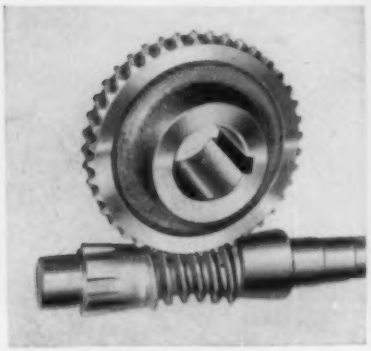
4—Backlash can be controlled or eliminated if desired.

continued, next page

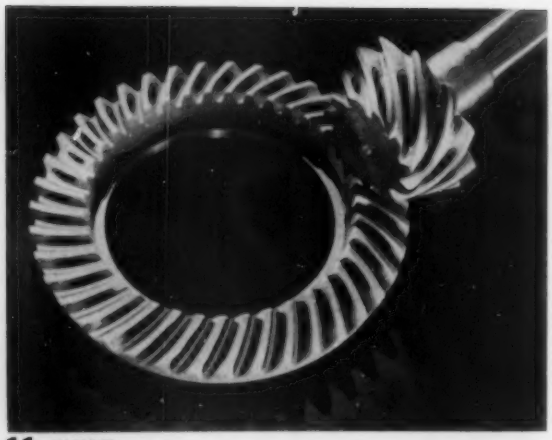
8 CROSSED HELICAL



9 WORM



10 CONE DRIVE



11 HYPOID

12 OFFSET FACE GEAR

Low power capacity of a pair of Beveloid gears is the major limitation. This is because point contact is produced on the meshing surfaces. Another limitation is undercutting when small numbers of teeth or large cone angles are used.

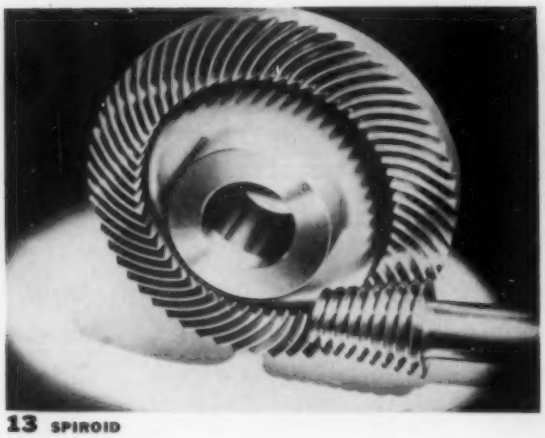
Crossed-helical gears

Both members are involute helicoids made on cylindrical blanks. The teeth do not taper. One main advantage is mounting ease. Crossed-helical gears are not sensitive to axial movement of either member or to small changes in shaft angle or center distance. Low cost is another advantage—either member can be made by any of the methods for ordinary helical gears.

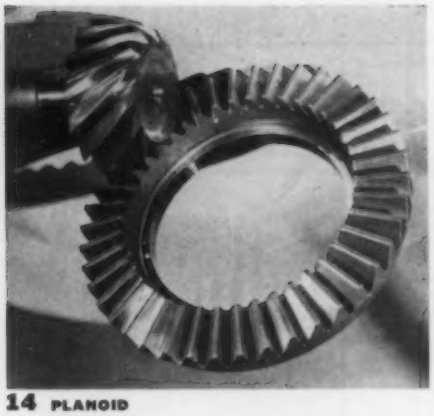
The teeth mesh is a point of contact, which limits the load that can be transmitted. However, this changes to line contact as the gears wear in.

Cylindrical-worm gears

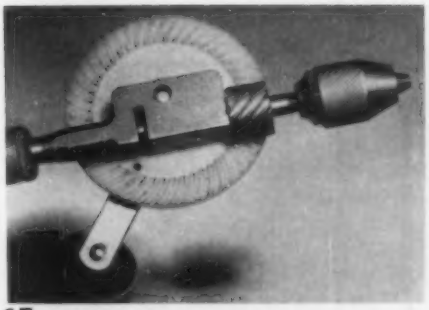
This system employs a single-enveloping worm that resembles a threaded screw; the thread is either straight-sided or slightly curved by action of the straight-sided cutter that makes the worm (a worm employing an involute tooth form is made by De Laval Holroyd Co). The gear is hobbed on a "throated" cylindrical blank, with a hob that is an exact duplicate of the worm. The gear teeth are curved and each end of the tooth is thicker than the middle.



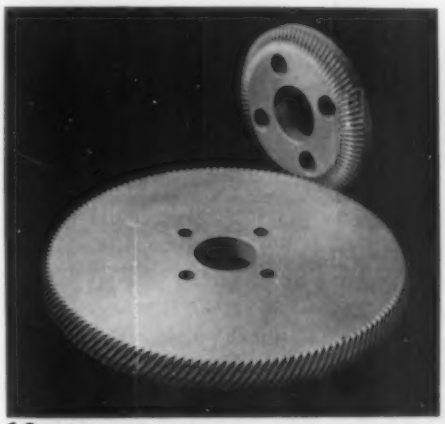
13 SPIROID



14 PLANOID



15 HELICON



16 OFFSET BEVELOID

The cylindrical worm has greater load-carrying capacity than the crossed-helical type because line contact is produced instead of point contact. However, mounting dimensions are more critical because the throated member must be positioned to wrap properly around the pinion.

Cone-drive or double-enveloping worm gears

The worm has an hour-glass shape and is cut by a straight-sided cutter representing the central plane of the gear. The gear, in turn, is hobbed by a hob that is an exact duplicate of the worm.

Because both worm and worm wheel are throated to wrap around each other, more tooth surface is in contact at any instant. This increases the load capacity but also increases the rate at which heat is generated. All mounting dimensions of a double-enveloping worm drive must be accurately held because the axial locations of both members are critical along with center distances and shaft angles.

Spiroid gears

The pinion of this system has a screw thread on a tapered blank. The thread is essentially a straight-sided "V". The gear is cut by a tapered hob that is an exact duplicate of the pinion. Gear teeth are cut on a sloping end-face of the blank.

Spiroid gears are relatively new in the trade, but have found wide usage in high- and medium-ratio applications, and where backlash control is important.

Planoid gears

The Planoid gear has straight-sided teeth cut on a sloping end-face of the gear blank. The teeth taper. The pinion is cut by a cutter that duplicates the gear. Planoid gears are employed for low-ratio applications up to 8:1. They are relatively new in the field.

Helicon gears

The pinion has a screw thread on a cylindrical blank. The gear is cut by a hob that duplicates the pinion. The gear teeth are on a slightly sloping endface of the blank. The Helicon and Spiroid are similar except for the taper in the pinion. Also Helicon gears can be manufactured for lower ratios.

COMPARISON—OPERATING CHARACTERISTICS

Table I, next page, compares gear systems with respect to power-to-weight ratio, efficiency range, ratio range, maximum horsepower, maximum pitch velocity,

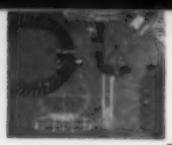


Table 1—Characteristics of the 16 Right-angle Gear Systems

Class	Type	Power-to-Weight Ratio	Efficiency Range	Ratio Range	Maximum Hp (per mesh)	Maximum Pitch Line Velocity, ft/min.	
						Commercial	Aircraft
Coplanar	1–Straight bevel 2–Coniflex[1] bevel	Medium High	97–99.5	1:1 to 8:1	500	1000	10,000
	3–Spiral bevel	Very High	97–99.5	1:1 to 8:1	5000	8000	25,000
	4–Zerol[1] bevel	High	97–99.5	1:1 to 8:1	1000	1000	10,000
	5–Revacycle[1] bevel	High	97–99.5	1:1 to 8:1	100	1000	———
	6–Face gear	Medium High	97–99.5	3:1 to 8:1	200	4000	5000
	7–Beveloid[2]	Low	97–99	1:1 to 8:1	150	4000	5000
Offset	8–Crossed helical	Low	50–95	1:1 to 100:1	100	4000	10,000
	9–Cylindrical worm	Medium High	50–98	3:1 to 100:1	750	5000	10,000
	10–Cone-Drive[3]	Medium High	50–98	3:1 to 100:1	1000	4000	10,000
	11–Hypoid, Low ratio High ratio	 High Medium High	 85–98 50–90	 1:1 to 10:1 10:1 to 50:1	 1000 500	 6000 Same	 10,000 Same
	12–Face Gear	Medium High	70–98	3:1 to 8:1	200	4000	5000
	13–Spiroid[4]	Medium High	50–98	9:1 to 100:1	500	6000	10,000
	14–Planoid[4]	High	70–98	1.5:1 to 8:1	1000	4000	10,000
	15–Helicon[4]	Medium High	50–98	3:1 to 100:1	100	6000	10,000
	16–Beveloid[2]	Low	70–98	1:1 to 8:1	150	4000	5000

Registered Tradenames:

[1]*Zerol, Coniflex* and *Revacycle*—Gleason Works, Rochester, NY; [2]*Beveloid*—Vinco Corp, Detroit; [3]*Cone-Drive*—Cone-Drive Div, Michigan Tool Co, Detroit; [4]*Spiroid, Helicon* and *Planoid*—Spiroid Div, Illinois Tool Works, Chicago.

type of contact and mounting sensitivity. All are nominal values which can be exceeded at times by special design. These values, as in later tables, have been calculated by the use of AGMA standards where available, gear-manufacturers' data, and test data and engineering analyses compiled at the General Electric Co. Thus the values are guideposts representing the judgment of the authors rather than fixed values in the gear trade.

For example, a few worm gears for aircraft have been built with pitch-line speed above 20,000 ft/min. But these jobs have been critical on accuracy, surface finish and lubrication. Hence, 10,000 ft/min. is a good nominal upper limit.

Sensitivity in mounting

When gears are mounted they may have to be set precisely in one or more of the following directions:

- In direction of pinion axis
- In direction of gear axis
- In direction perpendicular to both axes

In addition it may be critical to have the axes exactly at 90° to each other.

When a gear is "critical" in a mounting direction the part generally has to be within 0.001 in. or less of true location. When a gear is not critical, errors in mounting of the order of 0.010 in. or more have usually only a negligible effect on gear tooth action. If errors in mounting between 0.001 and 0.010 can be tolerated, the gear may be called "sensitive."

The crossed-helical gear is often picked for low-horsepower jobs because it is quite insensitive to mounting errors. Beveloid gears are another type with low sensitivity. The face gear is critical only in one mounting

Type of Contact	Mounting Sensitivity
Line	Critical in 3 directions
Line	Critical in 3 directions
Line	Critical in 3 directions
Line	Critical in 3 directions
Line	Critical in 1 direction
Point	Not critical
Point	Not critical
Line	Sensitive in 2 directions
Line or area	Critical in 3 directions
Line	Critical in 3 directions
Same	Same
Line	Critical in 2 directions
Line	Critical in 2 directions
Line	Critical in 3 directions
Line	Critical in 2 directions
Point	Not Critical

direction and this is often an important consideration in choosing it over another type.

Power characteristics

The power a gear set can transmit depends on its ratio, speed, size, hardness of material, and quality. Even when the designer wants the most power and will consider any size, ratio or kind of material there is a fairly well-defined upper limit of horsepower for each gear type. The upper limit is set by limitations in available manufacturing equipment, pitch-line velocity and lubrication problems.

Table I can be used as a guide on power capabilities. If a gear system must handle 2000 hp, the table shows that a crossed-helical gear would be out of the question—and that a spiral bevel could undoubtedly be designed to do the job. This much horsepower is also too high for a worm gear or Cone-Drive. Spiral bevels are being considered on some special jobs up to 20,000 horsepower, although the table shows a nominal upper limit of 5000 hp for spiral bevels. It is also possible to build worm gears to handle substantially more horsepower than shown in the table.

Nominal power capabilities of right-angle gears, based

Table 2—Power Capacity of Straight- or Zerol-bevel Gears

(For case-carburized pinion and gear, 55 RC min, pitch-line speed not over 1000 fpm; 20° pressure angle, full-depth tooth; theoretical face width not to exceed 0.28 cone distance)

Ratio, m_G	Pinion pitch dia, in.	Gear pitch dia, in.	Number pinion teeth	Face width, in.	Rpm of pinion			
					100	720	1750	3600
					Hp at different pinion speeds			
1	1.0	1.0	22	3/16	0.094	0.611	1.34	2.38
2	1.0	2.0	20	5/16	0.156	1.01	2.22	3.95
4	1.0	4.0	17	9/16	0.277	1.80	3.96	7.04
8	1.0	8.0	14	11/16	0.334	2.18	4.78	8.49
1	2.0	2.0	23	3/8	0.523	3.14	6.73	....
2	2.0	4.0	20	5/8	0.864	5.18	11.1	....
4	2.0	8.0	17	1 1/8	1.54	9.24	19.8	....
8	2.0	16.0	14	1 3/8	1.86	11.1	23.9	....
1	4.0	4.0	24	3/4	2.93	16.1	....	....
2	4.0	8.0	21	1 1/4	4.85	26.7	....	....
4	4.0	16.0	18	2 3/16	8.41	46.4	....	....
8	4.0	32.0	15	2 5/8	10.0	55.1	....	....
1	8.0	8.0	30	1 9/16	16.7	....	....	....
2	8.0	16.0	26	2 1/2	26.5	....	....	....
4	8.0	32.0	23	3 7/16	36.2	....	....	....

Table 3—Power Capacity of Spiral-bevel Gears

(For case-carburized pinion and gear, 55 RC min; pitch-line speed not over 4000 fpm; 20° pressure angle, full-depth tooth; 35° spiral angle; theoretical face-width not to exceed 0.30 cone distance; face-width rounded to nearest lower 1/32 in.)

Ratio, m_G	Pinion pitch dia, in.	Gear pitch dia, in.	Number pinion teeth	Face width, in.	Rpm of pinion				
					100	720	1750	3600	10,000
					Hp at different pinion speeds				
1	1.0	1.0	22	3/16	0.139	0.906	1.99	3.53	7.73
2	1.0	2.0	20	5/16	0.239	1.55	3.41	6.06	13.3
4	1.0	4.0	17	9/16	0.501	3.26	7.15	12.7	27.8
8	1.0	8.0	14	11/16	0.598	3.89	8.54	15.2	30.4
1	2.0	2.0	23	13/32	0.725	4.35	9.32	15.7	....
2	2.0	4.0	20	21/32	1.21	7.28	15.6	26.4	....
4	2.0	8.0	17	1 5/32	2.50	15.0	32.2	54.3	....
8	2.0	16.0	14	1 13/32	13.3	18.8	40.2	67.9	....
1	4.0	4.0	24	27/32	4.11	22.6	41.9	73.8	....
2	4.0	8.0	21	1 5/16	7.23	39.8	73.8	130.	....
4	4.0	16.0	18	2 7/32	13.4	73.8	137.	240.	....
8	4.0	32.0	15	2 21/32	16.0	88.1	163.	287.	....
1	8.0	8.0	30	1 11/16	24.4	120.	225.	....	....
2	8.0	16.0	26	2 21/32	42.5	209.	393.	....	....
4	8.0	32.0	23	3 15/32	56.8	280.	525.	....	....

on specific ranges of ratios, sizes and speeds, are given in Tables 2 to 8. The range shown is within the capability of the gear type, but generally the gears can be used over broader ranges of ratio, size and load. The tables give the general trend of rating practice for a gear type rather than a complete listing.

Values are for normal industrial practice with gears made to a good level of accuracy. If the same-size gears are made of the highest quality possible for aircraft practice, it is possible in many cases to go to horsepower ratings two or three times greater. This is particularly true at the higher speeds. Industrial gears have their ratings reduced at higher speeds because of dynamic tooth-loading effects. Aircraft gears are extremely accurate, and very lightweight for their size. They can carry almost the same tooth stresses at high speed as at low. Aircraft gears have very little derating for speed while industrial gears usually are derated substantially.

The gears were calculated for AGMA Class 1 service, which varies somewhat for each type of gear. Generally speaking, Class 1 is for about 10 hours' continuous service per day without recurrent shock loading ($K_s = 1$). Starting torque is generally held to less than 300% of rated torque at full speed and full rated horsepower. A steam turbine driving a generator would normally be a good example of a shock-free drive. A piston engine geared to a rock crusher would represent a drive with a serious shock problem—it would probably be necessary to rate a gear drive at less than half of its Class 1 rating.

Tables 2 and 3 are for case-hardened bevel gears. Bevel gears of good alloy steel at a hardness level of 33 to 38 Rockwell C (300 to 350 BHN) have ratings only 50% of those shown.

Table 4 gives ratings for face-gear sets of medium hardness. The pinion of a face-gear set has about the same capacity per inch of face as the pinion of a spur-gear set. Face gears can be case-hardened but there is no equipment to grind them. In small sizes it is possible to hold the gear distortion to a low value.

If the face-gear set was case-carburized and had good accuracy, capacity would be 200% of that shown.

Table 5 gives the nominal capacity of crossed-helical gears. Because these have a point contact they are rather sensitive to the method of breaking-in. The ratings assume that load is applied gradually and the units are polished-in without any metal-pickup occurring. The gears broaden their contact area as they wear and thereby reduce the stress in the contact area. Table 5 is based on a case-hardened steel driver and a phosphor bronze-driven gear. No particular gain in capacity can be obtained by case-hardening both members. At slow speeds a gain in capacity (100% or more) can be had by making both members out of a good cast iron. Field experience with cast iron crossed helicals has not been very good. There is a danger of sand inclusions in cast iron and this can lead to an abrupt, premature failure.

Tables 6 and 7 show the capacity of worm gears—Table 6 is based on a hardened-steel worm and centrifugally cast phosphor bronze wheel, and Table 7 on a hardened steel worm and chill-cast phosphor bronze wheel. Cast iron is sometimes used at slow speed.

Table 4—Straight-face Gears

(For pinion of 300 BHN min and gear 255 BHN min)

Ratio m_G	Pinion pitch dia, in.	Gear pitch dia, in.	Number pinion teeth	Face width, in.	Rpm of pinion			
					100	720	1750	3600
					Hp at different pinion speeds			
1.5	1.000	1.500	20	.085	0.018	0.116	0.251	0.440
	1.400	2.100	22	1/8	0.040	0.249	0.523	0.875
	2.000	3.000	24	11/64	0.105	0.637	1.29	2.00
	3.000	4.500	30	1/4	0.365	2.10	3.98	5.38
	4.000	6.000	36	23/64	0.899	4.96	8.79	9.92
	6.000	9.000	36	35/64	2.66	13.5	20.6	.....
2.0	1.000	2.000	20	9/64	0.024	0.154	0.334	0.586
	1.400	2.800	22	13/64	0.478	0.488	1.03	1.72
	2.000	4.000	24	19/64	0.194	1.18	2.38	3.70
	3.000	6.000	30	7/16	0.599	3.45	6.54	8.84
	4.000	8.000	36	37/64	1.38	7.62	13.5	15.2
	6.000	12.000	36	55/64	4.24	21.5	32.8	.....
4.0	1.000	4.000	20	3/8	0.073	0.466	1.01	1.77
	1.400	5.600	22	33/64	0.174	1.09	2.30	3.84
	2.000	8.000	24	23/32	0.491	2.97	6.01	9.34
	3.000	12.000	30	1 1/32	1.59	9.17	17.4	23.5

Table 6—Cylindrical Worm Gearing

(Sliding velocity not over 6000 fpm)

Ratio, m_G	Center distance, in.	Worm pitch dia, in.	Effective face width, in.	Rpm of worm				
				100	720	1750	3600	10,000
				Hp at different worm speeds				
5	2	0.825	1 15/32	0.30	1.6	2.8	3.5	5.0
8	2		1/2	0.20	0.9	2.1	2.6	3.9
15	2		15/32	0.15	0.7	1.4	1.9	3.4
25	2		15/32	0.10	0.5	1.0	1.4	2.9
50	2		15/32	0.03	0.3	0.5	0.7	1.0
5	4	1.525	7/8	2.1	9.7	14.5	18.5	23.0
8	4		15/16	1.8	6.8	10.6	14.2	19.0
15	4		15/16	0.9	4.6	7.0	8.8	11.3
25	4		15/16	0.6	3.0	4.8	6.7	8.6
50	4		15/16	0.4	1.6	2.6	4.2	5.2
5	8	2.800	1 11/16	12.0	44.5	66.6	86.0	....
8	8		1 13/16	8.0	32.5	48.0	65.0	....
15	8		1 13/16	5.5	23.0	33.5	47.0	....
25	8		1 13/16	4.0	15.2	22.0	34.0	....
50	8		1 13/16	2.1	8.0	11.3	20.0	....
5	16	5.100	3 1/8	65	190	265	350	....
8	16		3 3/8	50	140	210	265	....
15	16		3 3/8	36	100	145	185	....
25	16		3 3/8	23	66	100	130	....
50	16		3 3/8	12.5	30	50	75	....

Table 8 shows the nominal capacity of Spiroid gears, based on both members being case-hardened. The pinion can be ground, if need be, to achieve accuracy. The gear may be lapped after hardening. Spiroid sets can be made with a case-hardened pinion and a phosphor bronze gear. Ratings of these sets would be somewhat similar to cylindrical worm gears of the same size.

A hypoid gear has about the same rating as a spiral bevel gear of the same size. The hypoid pinion to go with a given hypoid gear is about 10% larger than a corresponding spiral bevel pinion. With this in mind

Table 5—Crossed-helical Gears

(For driver of 60 RC, and driven phos. bronze; pitch-line speed not over 4000 fpm; units given a short "break-in" run to polish contact area)

Ratio, m_G	Center distance in.	Helix angle of pinion, deg.	Pinion pitch dia. in.	Gear pitch dia. in.	Rpm of pinion				
					100	720	1750	3600	10,000
					Hp at different pinion speeds				
1	1.000	45	1.000	1.000	0.003	0.015	0.030	0.051	0.085
3	1.366	60	1.000	1.732	.006	.039	.082	.137	.228
5	1.9435	60	1.000	2.887	.010	.066	.139	.231	.385
8	1.572	75	1.000	2.144	0.19	.123	.260	.433	.720
1	2.000	45	2.000	2.000	.018	.117	2.45	.408	.....
3	2.732	60	2.000	3.464	.047	.312	.658	1.10	.....
5	3.887	60	2.000	5.774	.081	.528	1.11	1.85	.....
8	3.1435	75	2.000	4.287	.152	.988	2.08	3.46	.....
1	4.000	45	4.000	4.000	.143	.932	1.96	3.26	.....
3	5.464	60	4.000	6.928	.382	2.50	5.27	8.75	.....
5	7.7735	60	4.000	11.547	.646	4.22	8.90	14.8	.....
8	6.287	75	4.000	8.574	1.21	7.92	16.7	.....	.....
1	8.000	45	8.000	8.000	1.14	7.46	15.7	.....	.....
3	10.928	60	8.000	13.856	3.05	20.0	42.2	.....	.....
5	15.547	60	8.000	23.094	5.16	33.8	71.2	.....	.....

Table 7—Cone-Drive Worm Gearing

(Sliding velocity not over 6000 fpm)

Ratio, m_G	Center distance, in.	Worm pitch dia. in.	Rpm of worm				
			100	720	1750	3600	10,000
			Hp at different worm speeds				
5	2	0.830	0.35	1.72	2.96	4.20	6.20
15	2	0.830	0.15	0.77	1.40	1.86	2.65
50	2	0.850	0.05	0.25	0.45	0.66	0.98
5	4	1.730	3.0	12.9	19.8	25.6	34.5
15	4	1.550	1.27	5.95	9.64	13.0	17.8
50	4	1.660	0.39	1.82	3.07	4.22	5.60
5	8	3.450	24.4	84.4	119.2	148	.....
15	8	2.940	10.4	40.9	61.2	74.5	.....
50	8	2.900	3.28	12.8	19.5	24.5	.....
5	16	5.200	172	480	620	.....	.....
15	16	5.100	78	256	350	435	.....
50	16	5.100	25	85	119	139	.....
5	24	7.350	550	1420	1840	.....	.....
15	24	7.350	252	715	934	.....	.....
50	24	7.350	77.5	226	292	.....	.....

Table 8—Spiroid Gears

(Pinion and gear case-hardened, 60 RC min; pitch-line speed not over 1700 fpm; based on tooth proportions recommended by Spiroid Div., Illinois Tool Works)

Ratio, m_G	Center distance, in.	Pinion outside dia, in.	Gear outside dia, in.	Rpm of pinion				
				100	720	1750	3600	10,000
				Hp at different pinion speeds				
10,250	0.500	0.437	1.500	0.0142	0.0697	0.129	0.1948	0.3354
14.667	0.500	0.421	1.500	0.0120	0.0589	0.109	0.1645	0.2834
25.500	0.500	0.423	1.500	0.0088	0.0432	0.080	0.1208	0.2080
47.000	0.500	0.427	1.500	0.0064	0.0313	0.058	0.0876	0.1508
10.250	1.000	0.853	3.000	0.0937	0.4601	0.852	1.287	.....
14.667	1.000	0.821	3.000	0.0759	0.3726	0.690	1.042	.....
25.500	1.000	0.827	3.000	0.0550	0.2700	0.500	0.7550	.....
47.000	1.000	0.837	3.000	0.0377	0.1852	0.343	0.5197	.....
71.000	1.000	0.761	3.000	0.0299	0.1469	0.272	0.4107	.....
10.250	1.875	1.507	5.625	0.4961	2.435	4.51	6.810	.....
14.667	1.875	1.463	5.625	0.4125	2.025	3.75	5.663	.....
25.500	1.875	1.435	5.625	0.2915	1.431	2.65	4.002	.....
47.000	1.875	1.448	5.625	0.1804	0.8856	1.64	2.476	.....
71.000	1.875	1.308	5.625	0.1441	0.7074	1.31	1.978	.....
106.000	1.875	1.215	5.625	0.1188	0.5832	1.08	1.631	.....
10.200	3.250	2.395	9.750	2.101	10.31	19.1	.....	.....
14.667	3.250	2.465	9.750	1.760	8.64	16.0	.....	.....
25.500	3.250	2.319	9.750	1.21	5.94	11.0	.....	.....
47.000	3.250	2.344	9.750	0.7205	3.537	6.55	.....	.....
71.000	3.250	2.090	9.750	0.5544	2.722	5.04	.....	.....
106.000	3.250	1.933	9.750	0.4455	2.187	4.05	.....	.....
10.167	5.125	3.342	15.375	7.007	34.40	63.7	.....	.....
14.250	5.125	3.342	15.375	5.918	29.05	53.8	.....	.....
25.333	5.125	3.092	15.375	3.949	19.39	35.9	.....	.....
47.500	5.125	2.910	15.375	2.253	11.07	20.5	.....	.....
71.000	5.125	3.097	15.375	1.727	8.478	15.7	.....	.....
106.000	5.125	2.841	15.375	1.386	6.804	12.6	.....	.....

Table 3 can be used to estimate hypoid capacity.

Planoid sets are somewhat new on the market. Early field experience indicates that they have about the same capacity as hypoid gears of the same size.

Helicon gears span the ratio ranges of both Planoids and Spiroids. If made of the same material, Helicons have about 50% of the capacity of Planoids and about 80% capacity of Spiroids (for same size and ratio).

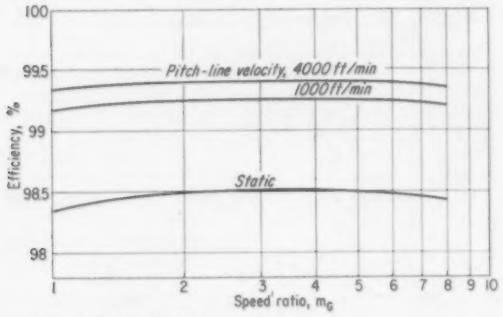
Beveloid gears can fit many applications—hence they can vary all the way from a close approach to the line-contact conditions of a bevel set to the point contact of crossed helicals. They are generally made with both members case-hardened and ground. Their capacity ranges from about 20% to 70% of that of equivalent-size straight-bevel gears.

Efficiency ranges

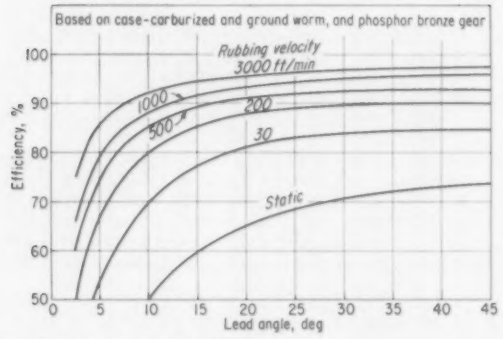
Efficiency of a gear is a variable. Factors such as surface finish, kind of lubricant, temperature of lubricant, and accuracy of teeth all affect the nominal values shown in the design curves, next page. The curves are based on the assumptions that the accuracy and finish of the gears represent good gear-industry practice for the type involved, that the oil used is petroleum oil of normal viscosity, and that the temperature range is normal (say, in the 80 to 120-F range).

Intensity of tooth load is very important. Suppose a gear set of 100-hp input capacity had a loss of 10 hp. This would mean 90% efficiency. At essentially no load

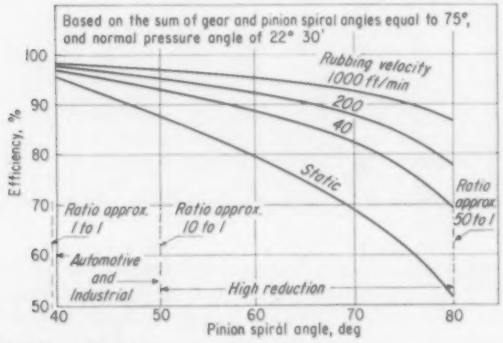
Efficiency Curves for different ratios and angles



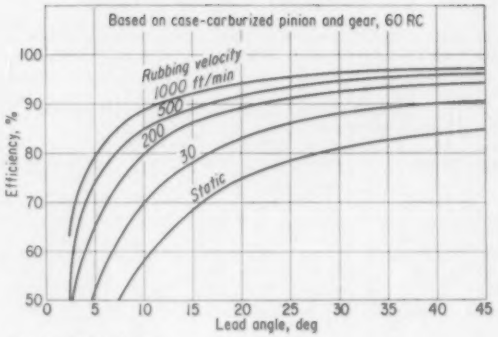
A—Spiral-bevel Gears



B—Cylindrical-worm Gears


Based on the sum of gear and pinion spiral angles equal to 75°, and normal pressure angle of 22° 30'
Rubbing velocity 1000 ft/min
200
40
Static
Ratio approx. 1 to 1
Ratio approx. 10 to 1
Ratio approx. 50 to 1
Automotive and Industrial
High reduction
Efficiency, %
Pinion spiral angle, deg

C—Hypoid Gears



D—Spiroid Gears

such a gear set might still have a mesh loss of as much as 3 hp. If only 1 hp was transmitted through the gear set, its efficiency would have dropped all the way from 90% to 25%. Efficiency curves for gear sets generally assume that full rated power is being transmitted through the gear set. On these two pages:

Curves A are for ground spiral-bevel gears operating at full load capacity for industrial applications. Their efficiency would be somewhat higher if operating as high-load aircraft gears with a thin synthetic oil.

Efficiency of straight-bevel and Zerol-bevel gears is quite close to this data. Face gears also follow the same trend but are somewhat less efficient because they are not usually loaded as heavily for their size as ground bevels. All these gear types are coplanar and have somewhat similar efficiency characteristics because of relatively low sliding velocity for a given pitch-line velocity.

Curves B show the efficiency of cylindrical worm gears as a function of worm lead angle. The efficiency drops off rapidly when the lead angle goes below 15°. However, in designs requiring low lead angles, horsepower is generally quite low and efficiency therefore is not too important a factor. In low-ratio units it is easy to design for a high worm lead angle but this becomes difficult at high ratios. **Curves E** give recommendations as to worm angle, center distance and ratio.

Crossed-helical gears (non-enveloping worm gears) follow a trend similar to that of cylindrical worm gears (Curves B), but tend to be less efficient because of their reduced load-carrying capacity. Double-enveloping worm gears such as Cone-Drive gears follow a similar trend to cylindrical worm gears.

Worm gears as a class all have a high sliding (or "rubbing") velocity with respect to the pitch-line velocity of the worm. The rubbing speed can be determined from:

$$v_r = \frac{0.262 n_W d}{\cos \lambda} \text{ fpm} \qquad (1)$$

where n_W = rpm of worm
d = pitch dia of worm, in.
D = pitch dia of gear

λ = lead angle; $\tan \lambda = \dfrac{D}{d m_G}$

m_G = speed ratio = $\dfrac{\text{No. gear teeth}}{\text{No. worm threads}}$

Curves C show the nominal efficiency of hypoid gears. Their efficiency pattern is somewhat similar to that of worm gears. The spiral angle of a hypoid pinion can be compared to the lead angle of worm by subtracting it from 90°. A hypoid pinion of 70° spiral is analagous to a worm with a 20° lead angle.

Hypoid gears have a lower rubbing speed in comparison to their pitch-line speed than do worm gears. This allows designing hypoid gears with better efficiency than worm gears to do the same job.

Curves D show some nominal efficiency data for Spiroid gears—the trend here is somewhat similar to that

of worm gears. Their rubbing velocity is not quite as high with respect to their pitch-line velocity as that of worm gears. Lead-angle recommendations are given in Curves F.

Planoid gears have rubbing characteristics very similar to hypoids, and their efficiency could be expected to follow a similar pattern.

Helicon gears are for lighter loads. Their efficiency is somewhat poorer than that of a Spiroid or a Planoid, but they follow a similar trend of best efficiency at a low ratio and poorest efficiency at a high ratio.

Beveloid gears may approach coplanar gears quite closely. This tends to give them relatively high efficiency. However, their relatively low load-carrying capacity tends to lower their efficiency. Fully loaded Beveloids generally have efficiencies in the 95% to 99% range.

All of the efficiency curves mentioned above are based on mesh loss of the gear teeth. In a complete unit there are bearing losses; there may also be significant windage losses and oil-churning losses. Though these other losses must be considered by the designer in figuring over-all efficiency, oil-cooler capacity, etc., they are generally not important enough to enter into the choice of kind of gear for a given job. Bearing losses, for instance, are usually less than 0.5% in a high horsepower application, while in some low horsepower applications, bearing losses can be as high as 10%.

SELF-LOCKING CHARACTERISTICS

Most gear sets are employed for speed reduction—their characteristics as speed increasers are usually of little concern. In a few cases, however, right-angle gear sets serve mainly to increase speed. Superchargers, for example, run at high speed and generally require a speed-increasing drive.

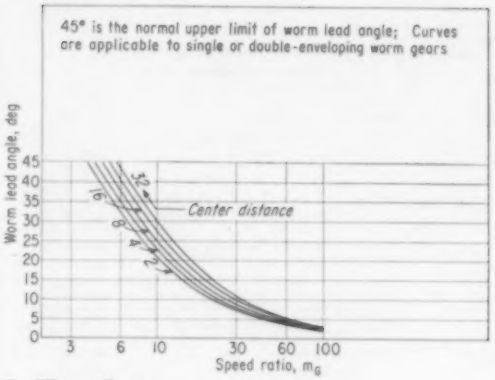
The efficiency of gear drives for this purpose may be much poorer than when running as speed decreasers. In general, a helical tooth form and a large number of teeth on the pinion help make speed increasers run smoothly and efficiently. High-ratio, straight-bevel gears; high-ratio, straight-face gears; and worm gears with a low lead angle are the poorest to use for stepping up speed. In fact, worm gears have the ability to self-lock when driven backwards—although high-lead-angle worms are very successfully used as speed increasers. One of the early supercharged automobiles had a Cone-Drive worm gear set driving the supercharger.

In some cases the ability to self-lock when driven backward may be a prime design requirement. A winch, for instance, can be designed so that stopping the drive self-locks the gears and holds the load. This may permit the use of a design without a brake or a ratchet. The gears alone may be adequate to hold the load.

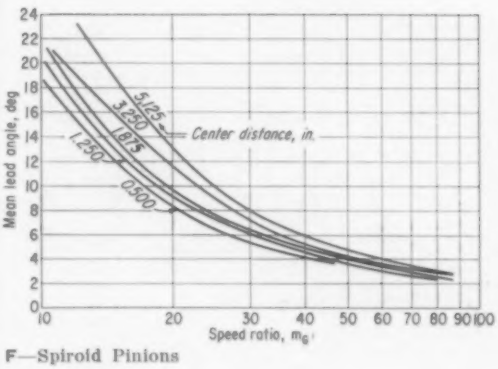
Best for self-locking are the single- or double-enveloping worm gears. Crossed helicals might be used but there is often some shock in self-locking. The stronger single- or still stronger double-enveloping worm gears are generally needed.

The exact lead angle at which self-locking occurs is somewhat variable, depending on kind of lubricant, tooth-surface finish and tooth proportions. The following rules will usually give satisfactory results.

Lead Angles for different ratios



E—Worm Gears



F—Spiroid Pinions

- For self-locking, the lead angle should not exceed 5°. In other words, the drive cannot be reversed with lead angles of 5° or less.
- If self-locking is desired, and the unit is already running when power is stopped and must then decelerate from speed, the helix angle should not exceed 3°.
- If appreciable vibration is present and a unit must stop when already running, the lead angle should not exceed 2° for self-locking.
- When a worm gear is to be driven backwards as a speed increaser, the lead angle should exceed 12°.

MANUFACTURING CONSIDERATIONS

Method of manufacturing can often determine which of several possible right-angle drives is best choice for a particular application. For example, if the quantity is low and cost is important, one might prefer a system manufactured with available or low-cost tooling.

A summary of common methods for manufacturing in the various right-angle gear systems is given in Table 9. It shows methods of producing both the pinion and gear member of each type, along with the processes currently being used to finish the teeth. Certain methods, such as casting or lapping, could apply to most types but are shown only where commonly used.

Machines designed and built by the Gleason Works

Table 9—Manufacturing and Finishing Methods

Gear Type	Member	Manufacturing Method	Refining Method
Straight bevel	Both	Forming rounded tools	.....
		Generating planing tools	.....
		Generating disk-mill cutters	Grind
Zerol bevel	Gear	Forming face mill cutters	Grind
	Both	Generating planing tools	.....
	Both	Generating face-mill cutters	Grind
Spiral bevel	Gear	Forming face-mill cutters	Grind, lap
	Both	Generating planing tools	Lap
	Both	Generating face-mill cutters	Grind, lap
Hypoid	Gear	Forming face-mill cutters	Lap or grind
	Both	Generating planing tools	Lap
	Both	Generating face-mill cutters	Grind or lap
High-reduction	Gear	Forming face-mill cutters	Grind or lap
	Pinion	Generating face-mill cutters	Grind or lap
Face gear	Pinion	Milling	Shave
		Broaching	Grind
		Hobbing	Lap
		Shaping	Hone
	Gear	Shaping	Lap
		Casting	
Crossed helical	Both	Hobbing	Shave
		Shaping	Grind
		Milling	Lap
			Hone
Beveloid	Both	Generating	Grind
		Hobbing	
		Casting	
Cylindrical worm	Worm	Milling	Grind
		Chasing	
		Hobbing	
	Wheel	Hobbing	Lap
Double-enveloping worm	Worm	Hobbing	Grind
			Lap
	Wheel	Hobbing	Grind
			Lap
Spiroid	Pinion	Milling	Grind
		Chase	Lap
		Rolling	
	Gear	Hobbing	Shave
		Casting	Lap
		Sintered	
		Molded	
Planoid	Pinion	Hobbing	Lap
			Shave
	Gear	Milling	Grind
		Broaching	Lap
Helicon	Pinion	Hobbing	Grind
		Rolling	Lap
		Milling	
		Chasing	
	Gear	Hobbing	Shave
		Casting	Lap
		Sintered	
		Molded	

are commonly used in the generation of either straight-bevel, Zerol-bevel, hypoid, or spiral-bevel gears and pinions. The fact that Zerol-bevel gears can be cut and ground on the same machines as spiral-bevel gears gives them one of their chief advantages over straight bevels.

The pinion of the face-gear set is merely a spur gear—hence, it can be made and finished by any of the methods used for parallel-axis spur gearing. The gear, however, must be shaper-cut or molded.

Both members of the crossed-helical pair can be manufactured with methods and equipment used for parallel-axis helical gearing. This is often very important if minimum tooling expense is desired.

Beveloid gears are generated on special machines, similar to hobbing machines, and are ground on machines similar to the hob-type grinders used to grind spur and helical gears.

With either cylindrical or double-enveloping worm gears, the worm wheel is generally made by hobbing, using either tangential- or radial-hob feed. The cylindrical worm is usually milled on a machine like a thread-milling machine or ground on a thread grinder. The double-enveloping worm is generally hobbed or shaped with a special attachment to obtain the throated form.

The Spiroid pinion can be manufactured on any machine set up for cutting a thread on a taper, such as a thread-milling machine with an angle block of some of the automatic thread-chasing machines. For high production, rolling the threads is very economical. The gear member must be machined in a hobbing machine, with a hob that duplicates the pinion.

The Planoid pinion is hobbed on a standard hobbing machine but with a special face-cutter mounted in the work spindle. The pinion to be cut is mounted in what is normally the hob spindle. The gear can be milled or broached one tooth at a time on standard machines.

Helicon pinions are made by milling, chasing, or hobbing in low-production quantities—or rolling where production is large. Their gears are hobbed with a hob which simulates the pinion. On ratios of less than 10:1, hobbing does not produce a satisfactory finish unless tangential-feed hobbing machines are used, so that below 10:1 the gear member is usually cast, molded or sintered.

REPRINT COPIES of this report are available for 25 cents each by addressing Reader Service Dept., Product Engineering, 330 W 42nd St, New York 36, NY.

EDITOR'S NOTE—The authors wish to thank the many individuals and organizations who helped in the preparation of this article, in particular: Wells Coleman of the Gleason Works; Fred Birtch, Cone-Drive Div of Michigan Tool; Fred Bohle and W. D. Nelson, Spiroid Div, Illinois Tool Works; Albert Beam, Vinco; J. E. Gutzwiller, Standard Products Div, DeLaval Steam Turbine Co. Photos of face and cross-helical gears are from Fellows Gear Shaper Co.

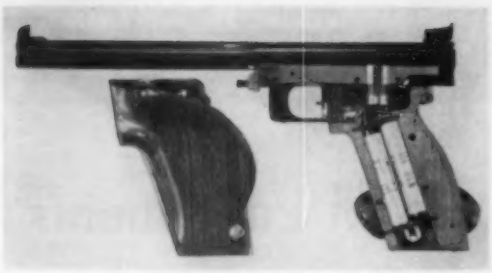
The authors also wish to point out they included information believed accurate and reliable. But because of the constant advance of technical knowledge, the widely differing conditions of possible specific application, and the ever-present possibility of misapplication, any application of the information must be, of course, at the discretion of the user.

For recent information on design of parallel-shaft gear systems see:

Latest Equations for Angular Errors in Gears, Aug 15 '60, p 56—Equations predict the effect of seven key factors.

Design Guide for Noncircular Gears, Mar 14 '60, p 59—Discussion of most types; equations, tables, and three design problems.

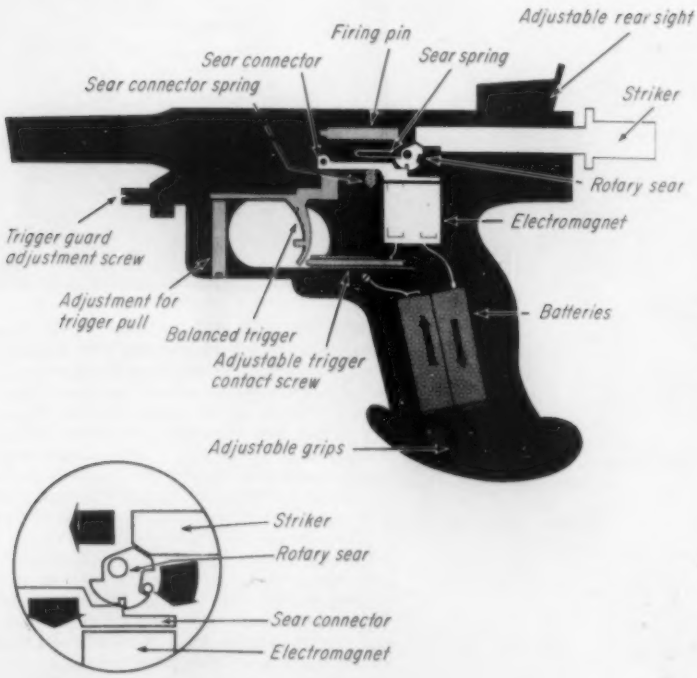
Twinworm—the Self-locking Gear, Jan 18 '60, p 39—New development combines two wormscrews to give self-locking characteristics.



"FREE" PISTOL gets its name from the lack of restrictions on its design. Safety was one of the primary goals here. Conventional pistols that have low trigger-pressure are so sensitive that a slight jolt or a change in temperature can cause accidental discharge. But this adjustable trigger can safely be set for as little as one-tenth ounce, because pressure between the sear and sear connector remains constant regardless of the trigger-pressure setting. Large wooden grip is moulded and slanted to individual shooters preference.

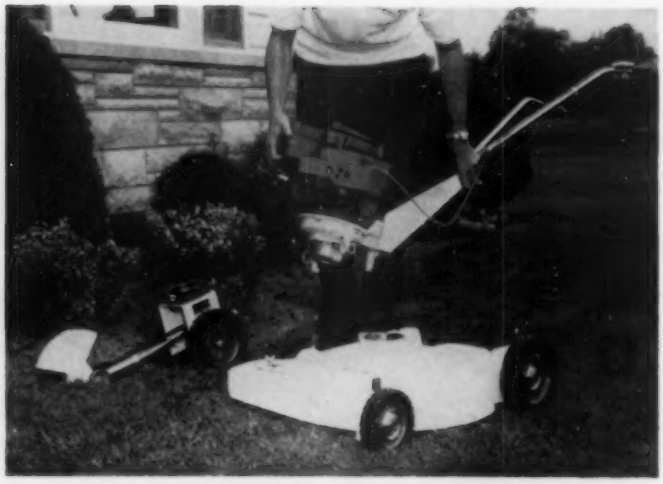
Batteries Trigger Target Pistol

Rotating sear in this free pistol holds striker safely in place until trigger is pulled. Then electromagnet disengages connector and weapon fires. Finger pressure required can be adjusted to as little as 1/10 oz.



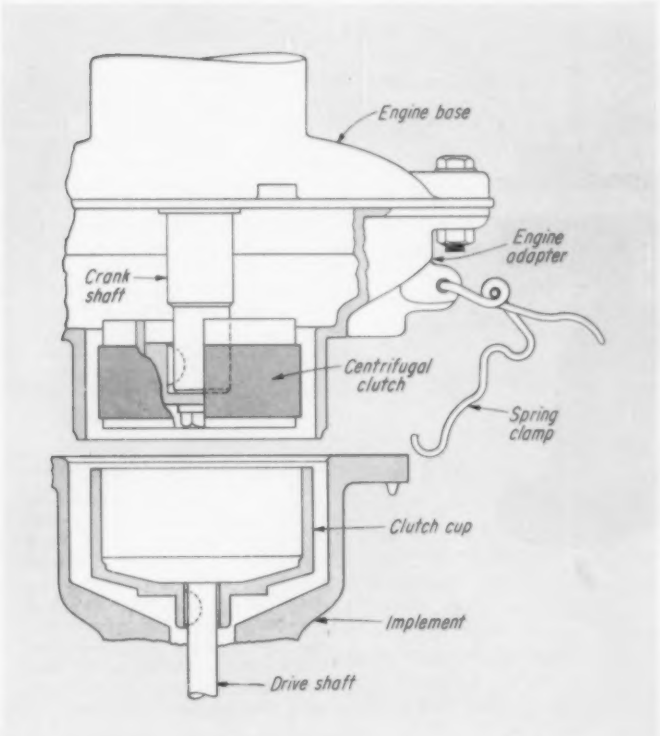
COCKED STRIKER is held back by rotary sear, which is locked by the sear connector. When trigger is pressed, completing the electrical circuit, electromagnet is energized, pulling the sear connector down. Pressure of striker rotates sear out of the way, allowing striker to move forward and hit the firing pin. When released, the striker moves forward in a straight line pushed by a coil spring exerting a 30 to 35-lb pressure. A downward movement of only 0.005 in. by the sear-connector releases the rotary sear and fires the pistol. Two 6.5-volt mercury batteries in the grip provide the current to operate the electromagnet.

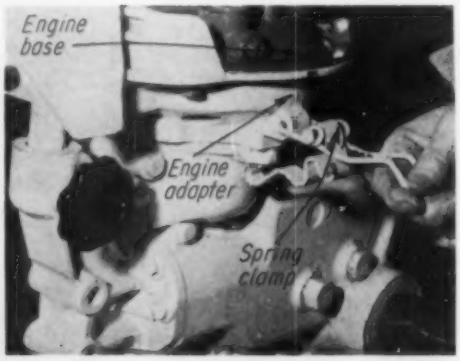
PS . . . Produced under contract for the US Army Advance Marksmanship Unit of Fort Benning, Ga, this .22-cal free pistol has been used in Olympic competition to fire at a target with a 1.1-in. bullseye placed 50 meters from the shooter. Fired from machine rest, the pistol produced shot groups from 0.425 to 0.575 in. at 50 meters. Pistol is produced by High Standard Mfg Corp. Hamden, Conn.



Engine Snaps Onto Choice of Implements

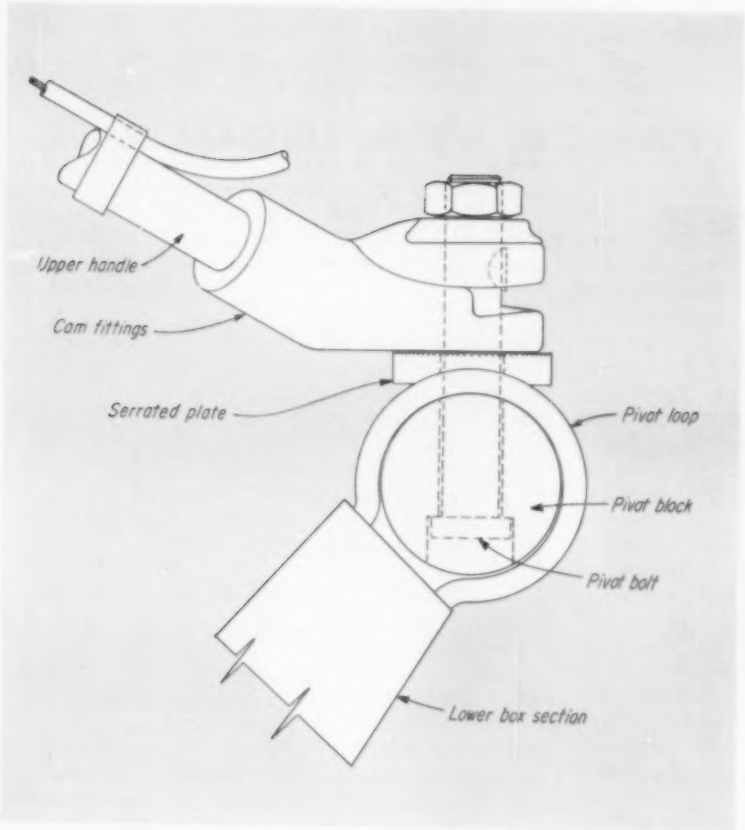
Centrifugal-clutch coupling permits transferring the power unit in seconds and without tools (photo shows it being lifted from mower to edge trimmer). Cam-action clamp gives freedom for positioning the handles.





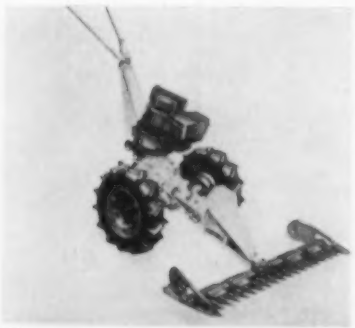
CLUTCH-COUPLING consists of a 3-segment centrifugal clutch which slips into mating cup on each implement. Vertical-shaft engine is mounted on an adapter which aligns the engine and tools. Spring clamps on each side of the adapter lock the engine and implement together. On smaller implements, dowel pins in the adaptors prevent rotation and movement. The locating pin at base of handle provides additional support when the heavier tools—tillers and tractors—are used.

When engine accelerates, centrifugal clutch begins to engage at 1200 rpm and locks fully at 1600 rpm. When decelerating, clutch starts releasing at 1600 rpm, is fully released at 1200 rpm. This reduces possibility of stalling to a minimum, and protects engine from overloads and the shock of implements striking heavy objects.



CONTROL HANDLE consists of the upper adjustable portion and a box-section lower-half bolted to the engine adapter. Upper and lower handles are connected by a universal pivot joint. Pressing the upper handles toward each other forces cam surfaces of the fittings apart, locking the pivot block to the loop. Slot in pivot loop permits handles to rotate 270° in a plane normal to the pivot block. Upper handles can rotate 360° around the bolt. For transport or storage, handles are folded over the engine. For tilling or plowing, handles can be offset to either side and allow operator to walk on firm ground.

(A)



(B)

(C)

(D)

FAMILY OF TOOLS powered by engine-handle combination include: (A) 21-in. self-propelled rotary mower, with transmission control attached by spring clips to the handle; (B) 32-in. sickle-bar mower attached to a two-wheel tractor; (C) lawn vacuumer which clears a 28-in. path with a centrifugal blower exhausting into a 4-bushel bag; (D) two-wheel tractor with two forward speeds, reverse and neutral controlled by a gearshift on the transmission housing.

PS . . . Interchangeable power unit has a 3.25-hp, 4-cycle engine equipped with impulse starter, weighs approximately 40 lb. Implements for the homeowner include walking and self-propeller 21-in. rotary mowers, a 22-in. tiller, an edge trimmer and lawn vacuumer. For individual users a 15-in. cultivator, 26-in. tiller-cultivator, 22-in. tiller and tractor for a plow or sickle-bar-mower are available. Terra Handle is produced by Moto-Mower Inc, subsidiary of Dura Corp, Richmond, Ind.

WHAT CAPACITANCE TRANSDUCERS HAVE TO OFFER

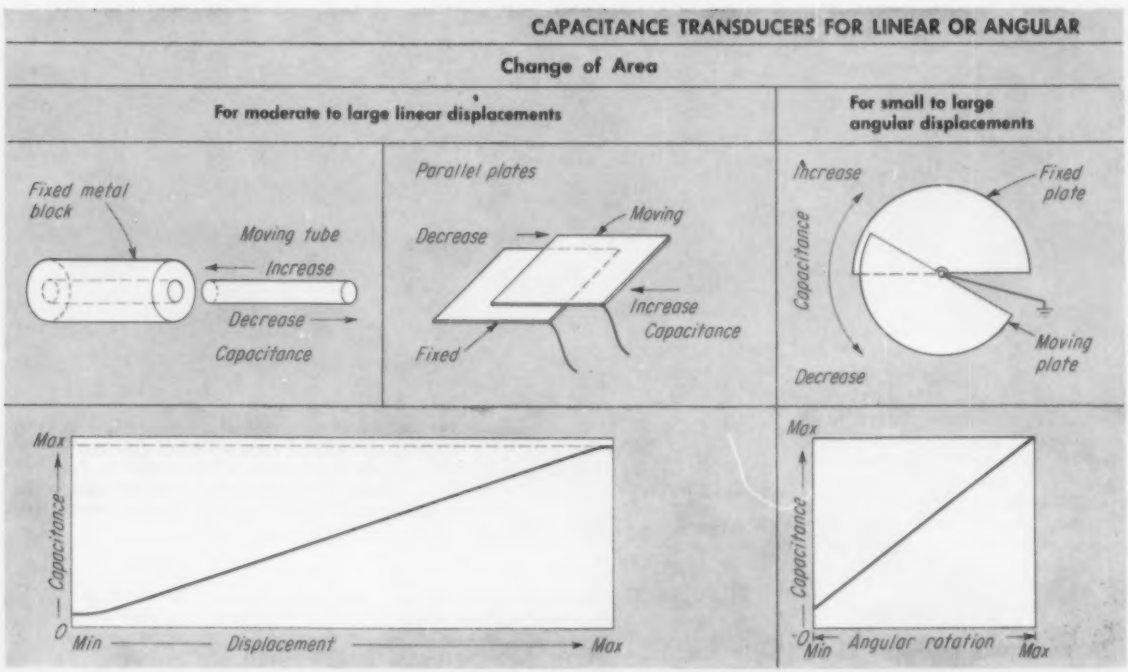
Pro...

High sensitivity to displacement
High-frequency response
High output
Little or no loading
Ability to measure both static and dynamic quantities

Con...

Relatively complex mechanical construction
Some temperature drift
Sensitivity to vibration
Possibility of spurious signals

J R McDERMOTT
Electronics consultant



BASIC TRANSDUCER TYPES fall into two categories: those that operate by changes in area (like the three above); and those that operate by changes in distance between plates (like the one on next page).

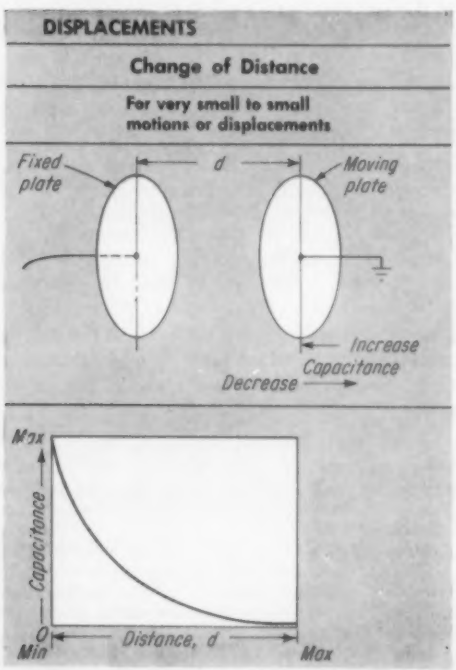
A prime advantage of the capacitance transducer is that it can be adapted to work with a wide variety of forms of mechanical construction. By proper design for a given application, wide ranges of basic quantities can be measured, including displacement, static position, force, pressure, and motion. Displacement can be measured from microinches to inches or even greater.

The capacitance transducer consists of two conductors separated by a dielectric. If we ignore any fringe effects, capacitance between two flat conductors or plates depends on these three factors: the dielectric constant of the medium between the plates, the facing areas of the plates, and distance between them.

A change in any of the three will result in a change in capacitance. Such transducers commonly operate by changing the distance between plates, or by varying their facing areas. However, in some special applications, such as measuring the level of a liquid, changed capacitance results from a change in the dielectric constant.

Measuring displacements

Medium or large displacements are best measured by applying the change-of-area principle. For example, to measure machine travel in terms of inches, a cylindrical metal tube can be mounted so as to move in or out of a concentric hole in a fixed block of metal. Where this telescoping type of construction cannot be used, it may be possible to adapt the parallel-plate type of construction. In either case the change–capacity versus displacement–can be linear, except for small increments at the maximum and minimum positions.



Curves below each type show changes in capacitance produced by changes in displacement.

Small displacements, in the order of microinches to a few thousandths of an inch, are frequently measured by a flexible diaphragm in which a change of distance between capacitor plates is the basic quantity varied. Because of this relatively high sensitivity to minute motions, the moving transducer can be made very stiff, so as to provide a high natural resonant frequency. For some transducers this has been as high as 500 kilocycles.

At other end of the range, where delicacy of measurement would be distorted by the measuring device, capacitance transducers that impose extremely light resistance or drag forces can be provided. In these respects they are exceeded only by optical devices.

Although the change of capacitance with distance between plates is inherently nonlinear, capacitance variation may be made linear by proper mechanical construction of the unit. Also, the electrical system from which the final output is taken may be adjusted to produce the required response.

Angular displacements can readily be measured by using a rotating-plate transducer. Here, depending on the required range, the transducer capacitance variation is usually linear, from very small angles to over 360°. If nonlinear response is required, the plates can be shaped to give the desired output curve.

Liquid levels are also measurable by capacitance changes. The level of nonconductive liquids can be measured by a change in dielectric constant of a gage transducer. The dielectric liquid rises or falls between two plates formed by concentric cylinders. Since the dielectric constant of such liquid is substantially greater than air, a rise in the liquid level increases effective capacitance. In such applications the capacitance change with level variation is essentially linear. Principal errors encountered are produced by change of dielectric constant with temperature.

For conductive liquids such as mercury, electrolytes or water, the change in capacitance between the liquid and a fixed plate above the liquid provides a variation in an ac output signal. The prime effect used here is a change in distance between two capacitor plates, one plate being the upper surface of the liquid. The output is nonlinear with respect to liquid variation.

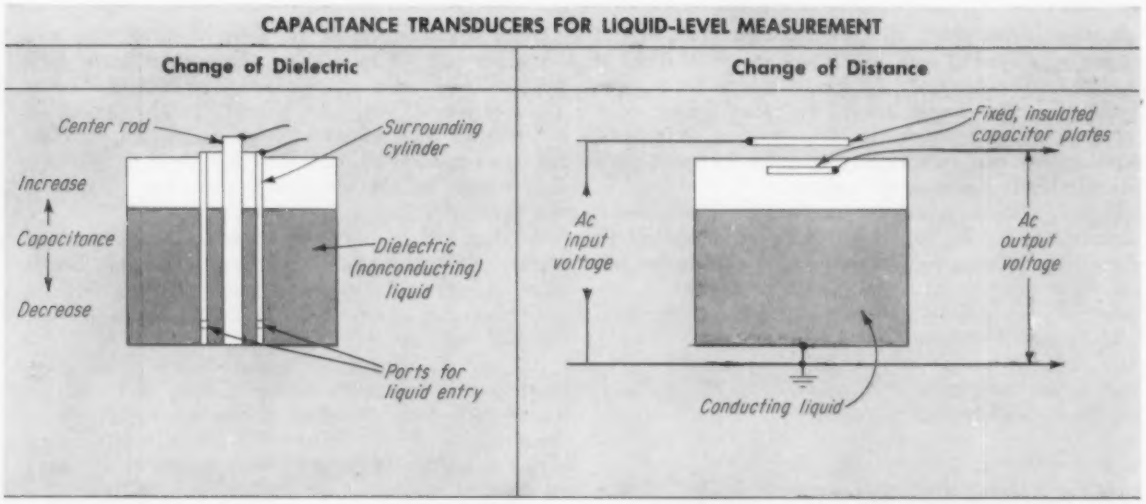
The ac excitation voltage, which may be low frequency, is applied between the upper plate and the liquid. The potential thus induces a charge and consequently a voltage on the lower fixed plate.

Transducer electrical systems

Several methods exist for converting variation in transducer capacitance into a useful electrical signal which can be applied for recording or control. The most common methods make the capacitor part of a tuned circuit.

For example, the transducer can be connected across the tuned circuit of an oscillator operating in the range of a few hundred kc to a few megacycles. A change in transducer capacitance increases or decreases the oscillator frequency. The output of the oscillator is applied to a standard frequency-deviation (also called frequency modulation) detector.

When the transducer is in "at rest" position–usually the center of the operating displacement range–and two



TWO LIQUID-LEVEL GAGES. For nonconducting liquid—use transducer at left. It operates on change of dielectric level between center rod and surrounding cylinder. Transducer at right is for a conducting liquid. Change of distance between lower capacitor plate and surface of liquid changes capacitance. Varying airgap is the dielectric.

tuned circuits are balanced—one tuned above and one below the oscillator frequency—the voltages delivered to the two load resistors are equal and opposite, therefore the net voltage at the output is zero.

If force or pressure is applied to increase the transducer capacitance, the oscillator frequency decreases, the output across one load resistor increases and that across the other decreases, and the net output voltage is negative. If force reduces transducer capacitance, the result is a positive output voltage. For cyclic variations in the measured quantity, this system produces a linear ac output whose frequency depends on the dynamics of the motion being measured.

The second most common type of circuit connects the transducer across a tuned circuit which is energized by the oscillator through inductive coupling. The main tuning capacitor has a relatively large variation which permits tuning the transducer circuit over a reasonably wide range. The operating point is set by adjusting this capacitor. The smaller variations of the transducer capacitor give an output which is rectified. The result is dc voltage over a limited range.

Because the variation is over a small region on the straight slope of the tuning curve, the output is linear. For dynamic (continuously changing) measurement, this output is a fluctuating dc signal.

Limitations

One basic reason for the versatility of capacitive transducers arises from the fact that dynamic response and the influence of temperature and pressure can be modified by mechanical construction to produce desired electrical characteristics. However, errors can result from the effect of humidity on the insulation that holds the plates in position, and from dirty environments that coat the insulation with conductive material. The capacitor must also be shielded from stray electric fields, which can induce random voltages in the ungrounded plate.

Coaxial cables connecting the transducer to the tuned circuits may be a source of spurious signals if they are mounted on areas of heavy or resonant vibration. Movement of the inner conductor produces changes in cable capacitance. Special cables are available to minimize changes.

Another method of reducing cable noise is to link-couple the transducer and the tuned circuit with which it is connected. This requires constructing a tuned circuit and a one- or two-turn link in the transducer itself.

EDITOR'S NOTE: For more information on force sensors, see:

How the Resistance Transducers Compare, Oct 17 '60, p 76—Describes seven types of resistance transducers; compares range, sensitivity, and linearity.

Better Accelerometers Off the Shelf, Sep 5 '60, p 54—Describes and compares six types of accelerometers used in testing, speed control, remote leveling, and balancing.

Piezoelectric Transducers Measure Fluctuating Forces, Pressures, Accelerations, Apr 27 '59, p 61—How piezoelectric accelerometers work; their limitations and applications.

Pressure-sensitive Material Measures Explosion Forces, or Footfall of a Fly, Sep 16 '57, p 106—Properties and application data on pressure cells made from rare earths. Cells change electrical resistance when compressed, thus serving as force transducers. Because of high sensitivity and output, they don't need amplification.

Three articles on application and design of strain-gage bridges:

Strain-gage Balancing Simplifies Multiple Bridge Measurements, June '56, p 161.

Strain-gage Transducers, March '56, p 196.

Strain-gage Bridge Sensitivity Control, Jan '56, p 200.

Do you know the quick ways to solve the Pythagorean relationship . . . want more accuracy when finding powers and roots? Here are 13 examples showing how to . . .

get more from your sliderule

CHARLES J LYNCH
Assistant editor

The standard 10-in. duplex (two-sided) sliderule is a remarkably versatile device. Yet some engineers, though they use it every day, fail to take full advantage of its potential. For example, it will solve several commonly encountered equations with a minimum of longhand arithmetic and algebraic substitution. Some users are also surprised to find it will give answers beyond the 3- and 4-place accuracy customarily considered the limit. Moreover, with the variety of scales supplied on modern rules, calculations that once required several settings and resettings can now be performed with minimum manipulations.

Of the twenty or more scales now on a rule, how many do you actually use? Have you reexamined your rule since the days when you were first becoming acquainted with it, to discover what scales are included and the purpose of each? For a reminder, here is a list of scales commonly found on the modern sliderule and the intended function of each as described in standard sliderule manuals. If you are not using each to its fullest potential you are denying yourself some of the worksavers built into your instrument.

C and **D**: multiplication and division.

DF and **CF** (folded scales): with C and D, to read answers that fall beyond the end of the scale without resetting slide. Also for finding products in which π is a factor.

DI, CI and **CIF** (reciprocal scales): reciprocals of numbers on D, C and CF. Also for "multiplication by division" in problems containing many factors to be multiplied together. (To reduce sliderule motion, divide by reciprocal, multiply, divide by reciprocal, multiply, etc.)

A and **B**: squares and square roots. Also for multiplication and division (with reduced accuracy) to avoid transferring readings back to C and D scales.

K: cube roots.

LL: for powers and roots other than squares or cubes. Also for finding logarithms to the base e. Most rules have five or more log-log scales.

S, T and **ST**: trigonometric functions—sines, cosines, tangents, cotangents.

Most rules also have an **L** scale. This is perhaps the most neglected of all scales: it's too slow to be much use for multiplication and division (the C and D scale are not only faster but just as accurate) and it is too short (slightly less than 10 in.) to pinch-hit as a ruler. Its chief uses are for plotting numbers logarithmically on a linear scale (read the $\log_{10}$ directly from the L scale) and for finding fractional roots and powers in lieu of the LL scale. The following problem is an example of the latter application.

EXAMPLE 1: Find $52^{2.7}$

The answer is larger than 22,000 and thus extends beyond the end of the log-log scales on most rules. Therefore, find mantissa of 52 on the L scale (0.716), add the characteristic (1.0), multiply the logarithm (1.716) by 2.7 on the C and D scales ($2.7 \times 1.716 = 4.63$). Now find antilog of 0.63 on L scale (4.27) and place decimal point in accordance with the characteristic.

$$52^{2.7} = 42{,}700$$

The L scale will also give more accurate answers for powers in which the result, though it can be read on the LL scale, is larger than 1000. Answers larger than 1000 cannot be read accurately on LL much beyond 2 places but answers found with L and D scales can always be read to three places, sometimes four. Accuracy here is limited by accuracy of final log. For best results, multiply exponent and log by longhand.

Roots on LL Scales

In the same way, it is sometimes more accurate to find square and cube roots with the LL scales than with the A and K scales. This is particularly true of numbers slightly larger or slightly smaller than 1.0, or numbers that can be reduced to this value by extracting appropriate powers of 10.

continued, next page

REPRINTED—Circle P66, inside back cover

EXAMPLE 2: Find $\sqrt{118.4}$

Reading the root from the A scale to the D scale in the normal way gives 10.89 (estimating the last significant digit). But reducing the root to

$$\sqrt{118.4} = \sqrt{1.184 \times 10^2} = \sqrt{1.184} \times 10$$

and reading the root of 1.184 on the LL scale gives 10.881

EXAMPLE 3: Find $\sqrt[5]{952.1}$

Extracting 10^5 and reading the answer on the LL scale gives

$$\sqrt[5]{0.9521 \times 10^5} = .98375 \times 10 = 9.8375$$

This compares to the 9.84 read when using K and D scales.

On some sliderules the LL scales will also find reciprocals of numbers to several significant places when the number is close to 1.0 (or 1.0×10^x, where x is a positive or negative integer). It is necessary that the rule have an LL scale for negative exponents that corresponds with each LL scale for positive exponents. On some rules these are marked LL1, LL2 and LL3 for positive exponent and LL01, LL02 and LL03 for negative exponents. On other rules the scales for positive and negative exponents are back-to-back. (Rules with LL0 and LL00 scales for negative exponents cannot be used for this operation.)

EXAMPLE 4: Find 1/1164

Rewrite as:

$$\frac{1}{1164} = \frac{10^{-3}}{1.164}$$

Read 1.164 on LL2 and 0.8592 on LL02

$$\frac{1}{1164} = .8592 \times 10^{-3} = 0.0008592$$

Another way to find square roots to several significant figures is to use the sliderule to approximate the root. Find the first approximation with the A scale in the usual way. Then divide this by longhand into the original number to find a second approximation. The average of the first and second approximations is the square root to four or more significant digits.

EXAMPLE 5: Find $\sqrt{16.83}$

With sliderule, read 4.11
divide manually: 16.83/4.11 = 4.0951
find average: (4.11 − 4.0951)2 = 4.1025
check: $(4.1025)^2 = 16.8305$

Because of the manual long division, the method is slow. But it is faster than extracting the root by hand (an operation most of us have forgotten how to do, anyway) when you don't have 5-place log tables handy.

Multiplication by π

The folded scales are most convenient for finding circumferences of circles: with the cursor, simply read the diameter on the D and the circumference on the DF. Areas are found quickly on the A scale by setting the index to the radius on the D and reading the area on the A opposite π marked on the B. But there are many occasions when multiplication or division by π must be performed on the C and D scales. Generally, these scales have no π calibration so that it is necessary to read 3.142 each time the factor is used. You can mark π on the C and D scales by dividing 355 by 113 and scribing a line opposite the index, using a sharp knife and a steel straightedge. (The factors in the division are easy to remember: They are the last three digits of the sequence 113355, divided by the first three digits. This gives π accurate to seven significant digits.)

Despite notions to the contrary, addition and subtraction can be performed on the sliderule. Consider the problem 173 + 95 = ?. To solve it, first rewrite the problem by multiplying and dividing both factors by the smaller factor to give 95 (173/95 + 1). Then, on the sliderule, divide 173 by 95, mentally add 1, reset the index to (173/95 + 1) and multiply by 95. This, of course, is slow, more cumbersome, and less accurate than pencil and paper addition (this particular problem could even be done mentally) but there are variations of the problem that make the method useful.

One frequently recurring variation is the solution of the Pythagorean equation. Rewriting the equation

$$c = \sqrt{a^2 + b^2}$$

as

$$c = a\sqrt{\left(\frac{b}{a}\right)^2 + 1}$$

it can be solved on the sliderule without pencil-and-paper addition. In rewriting the equation, divide by the square of the smaller of the two sides so that b/a is greater than 1. This simplifies the mental addition.

EXAMPLE 6: Find the resultant of two forces acting at 90°. The forces are 78 lb and 164 lb.

$$C = 78\sqrt{\left(\frac{164}{78}\right)^2 + 1}$$

Set 164 on D opposite 78 on C. Read $(164/78)^2$ on A (4.42) and add 1 (5.42). Reset index to 5.42. Read answer (181.7) on D opposite 78 on C.

If hypotenuse and one leg are known, the other leg can be found by subtraction.

EXAMPLE 7: Resultant velocity of a projectile is 613 fps. If one of two mutually perpendicular components is 381 fps, find the other component.

$$a = 381\sqrt{\left(\frac{613}{381}\right)^2 - 1}$$

As before, divide 613 by 381 and read $(613/381)^2$ on A. Subtract 1 (2.59 − 1 = 1.59), reset index, and read answer, 480, on D, opposite 381 on C.

There's another way to perform these operations on the sliderule but, though it saves one step, it is not so straightforward and therefore more difficult to remember.

EXAMPLE 8: Find resultant impedance when a resistance of 72 ohms is connected in series with an inductance of 15 ohms.

$$Z = 15\sqrt{\left(\frac{72}{15}\right)^2 + 1}$$

Divide 72 by 15 "upside down." That is, set cursor to 15 on D and slide 72 on C under hairline. Without moving cursor, read $(72/15)^2$ opposite index on B and reset slide to $(72/15)^2 + 1 = 24.1$. Now read resultant (73.6 ohms) under hairline on C.

When the ratio between the two sides of the triangle is large (greater than about 5 to 1) it is usually more accurate to solve the triangle in the normal way, using the trigonometric scales. There is a shortcut here too.

To find hypotenuse:

Set index over larger side on D
set hairline over smaller side on D
read θ on T
draw slide under θ on S
read hypotenuse on D under index.

When hypotenuse and one leg are known, the other leg can be found in a similar fashion.

The method of sliderule addition can also be useful for the following equations, frequently found in electrical computation:

$$\frac{1}{a} = \frac{1}{b} + \frac{1}{c}$$

$$\frac{1}{a^2} = \frac{1}{b^2} + \frac{1}{c^2}$$

They can be solved by sliderule if rewritten

$$a = \frac{b}{1 + b/c}$$

$$a^2 = \frac{b^2}{1 + \left(\frac{b}{c}\right)^2}$$

These are best solved by first finding 1/a (working the problem "upside down") and then finding the reciprocal. If your sliderule has a DI scale, the problems can be solved with one less step.

Backward-reading Scales

Engineers who make frequent computations with the sliderule have a trick for computing equations of the form

$$x = 1 - y$$

where y is a number that must be computed by sliderule before the subtraction. Rather than subtract y from 1, simply read the answer directly pretending that the rule is calibrated from right to left rather than left to right. Hence, where the D scale is marked 9, read 2; where it is marked 8, read 3, etc. The other graduations can be read as easily from the right as from the left since they have no calibration figure.

EXAMPLE 9: $1 - 67.2/78.1$

Divide 67.2 by 78.1 the usual way (with 67.2 on D and 78.1 on C). Under index read 0.240 (actually 0.860) counting from right.

The method works best when the value of y is only slightly smaller than 1, causing the answer to fall close to the right of the scale.

Here's another trick: When ratios are close to 1.0, compute smaller portions of ratio and subtract from 1 (or add to 1) for a more accurate answer.

EXAMPLE 10: 731/756

By the usual method of division the answer is 0.967 as close as it can be read. But by rewriting (it can usually be done mentally) in the form

$$1 + \frac{731}{756} - 1 = 1 - \frac{756 - 731}{756} = 1 - \frac{25}{756}$$

Then, by sliderule, compute

$$1 - \frac{25}{756} = 1 - 0.0331 = 0.9669$$

Or when the ratio is slightly larger than 1.0, as in

EXAMPLE 11: $\frac{1.972}{1.863} = 1.059$ by sliderule,

compute instead:

$$1 + \frac{1.972 - 1.863}{1.863} = 1 + \frac{0.109}{1.863} = 1.0585$$

Or when multiplying factors, one of which is close to 1.0 as in

EXAMPLE 12:

$(0.9548)(731) = 698$ by sliderule,

multiply instead:

$$\begin{aligned}(-1 + 0.9548 + 1)(731) &= 731 - (1.0 - 0.9548)(731)\\ &= 731 - (0.0452)(731)\\ &= 731 - 33.05 = 697.95\end{aligned}$$

Solving quadratic equations on the sliderule is not a simple matter–but sometimes faster than the binominal theorem. Though the method is reasonably straightforward, it demands considerable cut-and-try.

First step is to rewrite the equation with the coefficient of the x^2 term unity in the form:

$$x^2 + bx + c = 0$$

Set the index of the sliderule over c on the D scale and find the factors on the D and CI scales whose sum is b. (If the last term is negative, find the factors whose difference is b.)

EXAMPLE 13: Find factors in the equation

$$21x^2 + 137x - 434 = 0$$

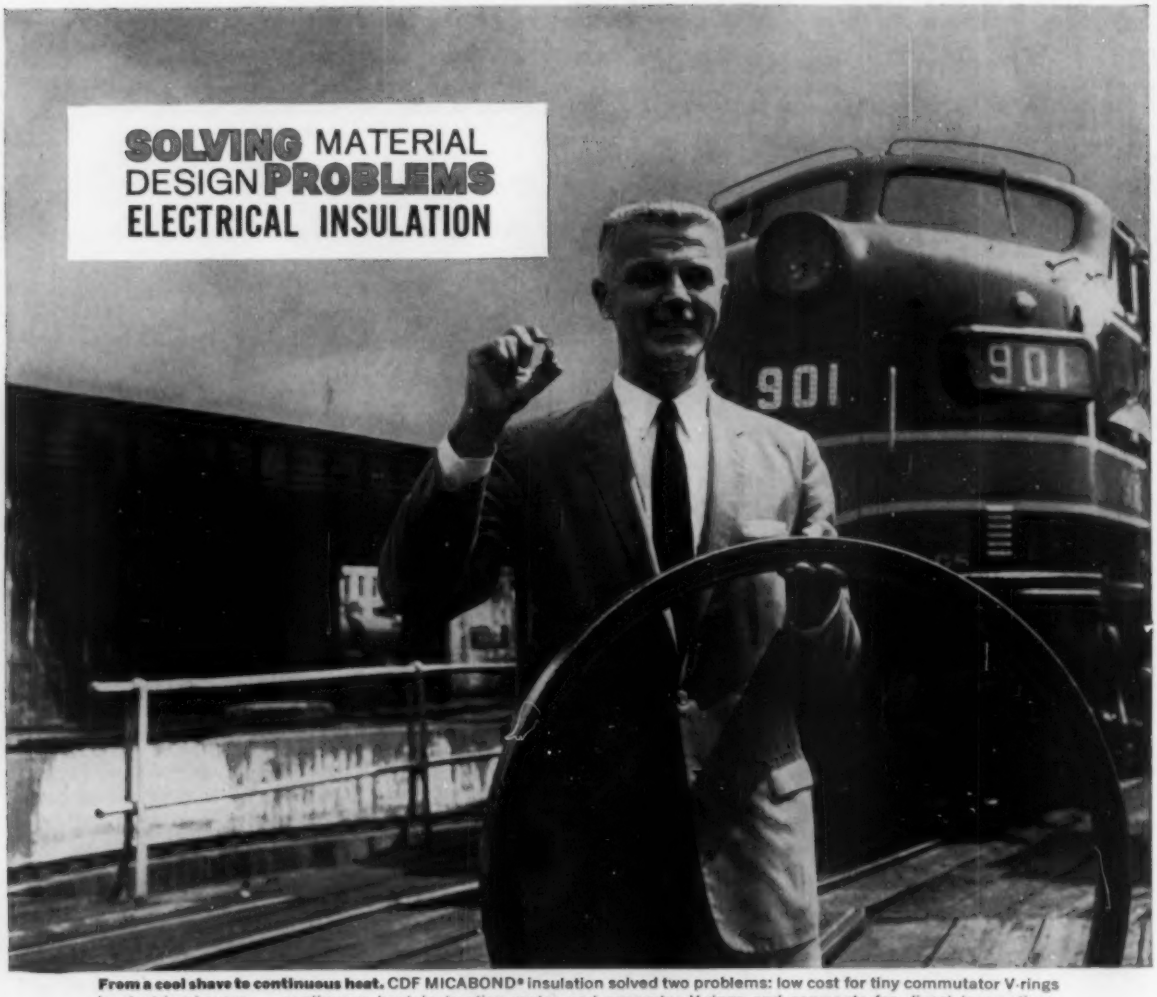
Rewrite: $x^2 + 6.52x - 20.7 = 0$

Set index to 20.7 on D and read off pairs of numbers under the hairline on CI and D scales. First bracket the factors by finding a pair whose difference is larger than 6.52 and a pair whose difference is smaller. Don't worry about decimal points—assume whatever decimal-point placement is needed to give a difference in the desired range. After numerous trials and several pencil-and-paper subtractions, you will discover the nearest pair:

$$x = -8.86 \quad x = 2.33$$

Third- and fourth-order equations can also be solved in a similar fashion (using square root and cube root scales) but the method requires considerable practice to gain facility with the technique and confidence in the result. There's no quick way to solve higher order equations (short of a computer). For those infrequent occasions when a cubic or quartic must be solved, it's probably more expedient to turn to the handbook solutions. ■

For REPRINT of above article, just check P66 on one of the Reader Service cards found in this issue.



From a cool shave to continuous heat. CDF MICABOND® insulation solved two problems: low cost for tiny commutator V-rings in electric shavers . . . continuous heat in traction motor and generator V-rings and segments for diesel locomotives.

You get the exact physical and electrical properties you want at low cost when you have a wide selection of grades to choose from, plus engineering know-how to help you with your selection.

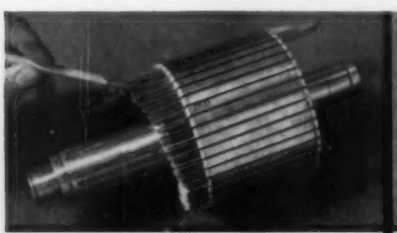
The many grades and types of MICABOND made it comparatively easy to solve the different insulation problems posed by low cost shaver motors and rugged locomotive traction motors and generators.

In addition to the MICABOND line, CDF makes the industry's widest range of laminated plastics, vulcanized fibre, and other electrical insulating materials. For MICABOND information, write us for catalog M-59. For other product information, ask for General Folder 60. Or check your Sweet's Product Design file.

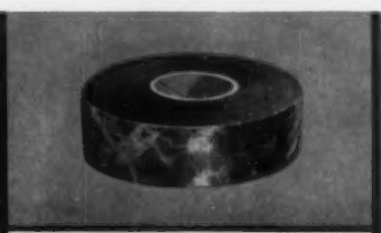
CONTINENTAL-DIAMOND FIBRE

A SUBSIDIARY OF THE Bakelite COMPANY • NEWARK 40, DEL.

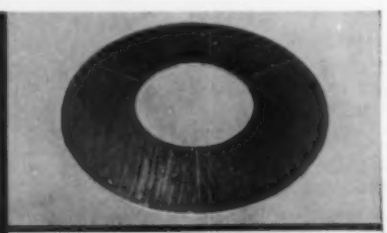
In Canada, 46 Hollinger Road, Toronto 16, Ont.



Long-life insulation. CDF MICABOND is used in low-cost slot-cell insulators in motor assemblies.



Flexible. CDF MICABOND tapes provide high heat resistance for many types of electrical windings.



Impact resistance. A reason why MICABOND was used as disc insulators for giant magnetic cranes.

SECTION MODULUS CHARTS FIND BEAM DIMENSIONS FASTER

This special version of the flexure equation quickly solves for stress, load and size of a given beam.

LOUIS DE MONGE, *research engineer with the firm of Colonel S H Bingham—Consultant Engineers, NYC*

Flexure formula $S = Mc/I$ links together outside forces, kind of material and beam shape. In a special case, when c is distance from neutral axis to the extreme fiber, the ratio I/c becomes known as section modulus, a summation of the effects of cross-section shape.

When the flexure equation includes this section modulus, three different solutions are possible:

- Highest stress in a cross-section
- Load that a specific shape can stand
- Necessary section modulus.

Knowing section modulus does not mean knowing exact size and shape of the piece; but once shape is chosen, dimensions follow. In the first two types of problems, charts give section modulus for a known beam. Curves with this article, for section modulus of tubes, I-beams and box beams, also show weight per foot of length.

EXAMPLE: One tube in the arm of a centrifuge for training astronauts must withstand a bending moment of 190,000 in.-lb. If stress limit for the material is 50,000 psi, what shall tube diameter and wall thickness be? How much weight does the tube add?

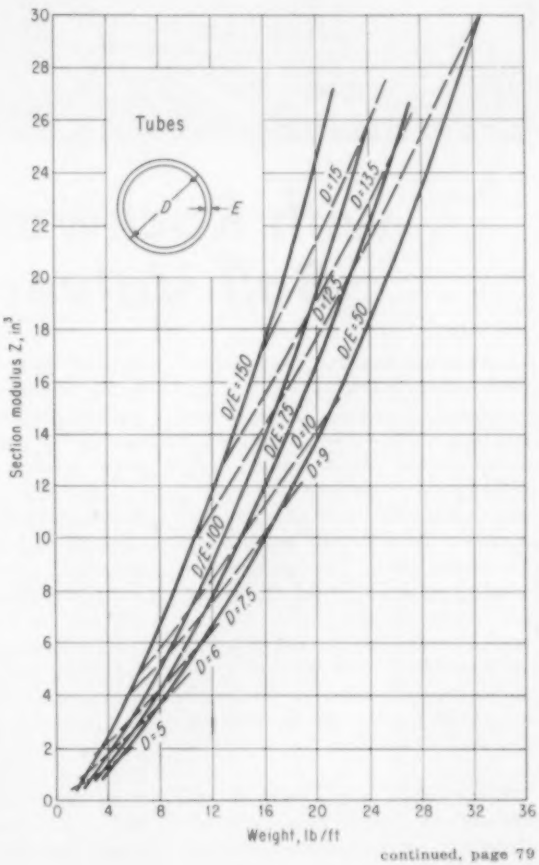
SOLUTION: Start by finding section modulus.

$$Z = M/S$$
$$= 19 \times 10^4/5 \times 10^4 = 3.8 \text{ in.}^3$$

From chart, $D = 6$ in. when $D/E = 50$, or $D = 9$ in. when $D/E = 160$.

Wall thickness $E = D/50 = 6/50 = 0.120$ in. for 6-in. tube; and $E = D/160 = 9/160 = 0.056$ in. for 9-in. tube.

The 6-in. tubing weighs 8.2 lb/ft; the 9-in. tubing, 5.2 lb/ft.

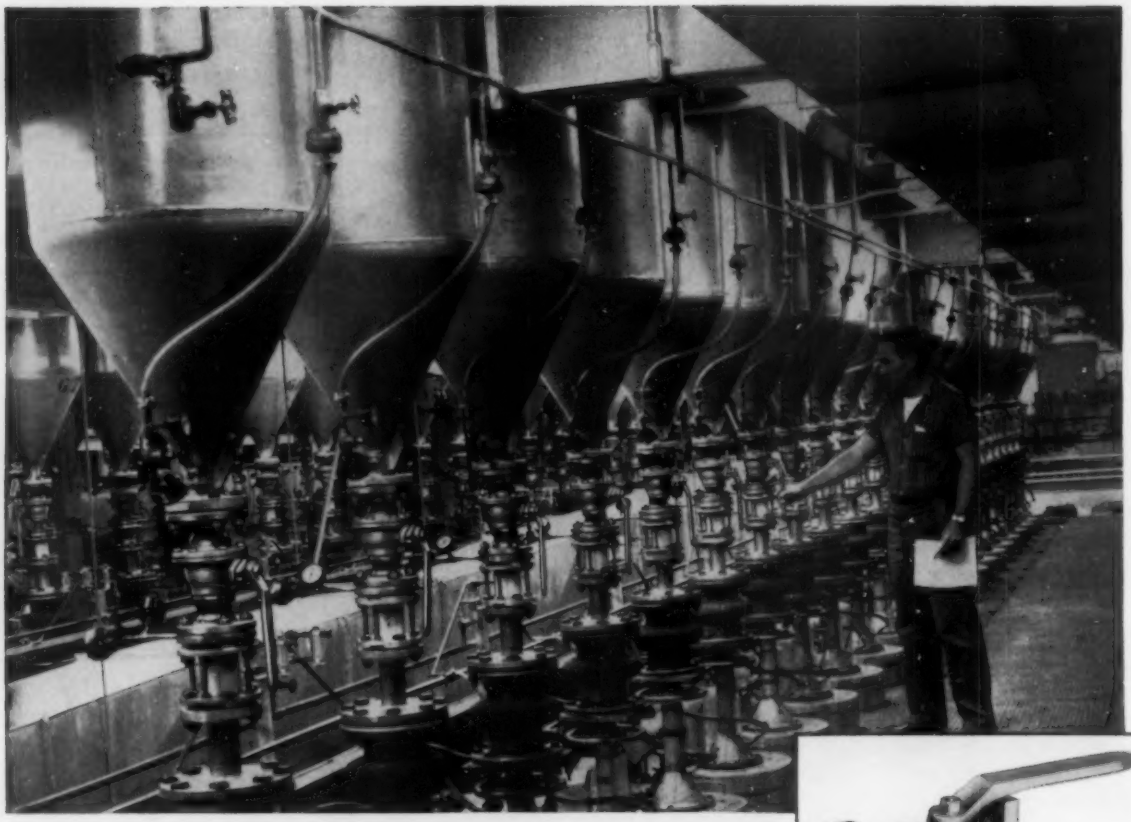


continued, page 79

SYMBOLS

B = Beam width, in.
c = Distance of fiber from neutral axis, in.
D = Tube outer diameter, in.
E = Web thickness of I-beams and wall thickness of tube, in.
E_1 = Flange thickness of I-beams and box beams, in.
E_2 = Web thickness of box beams, in.
I = Moment of inertia, in.⁴
M = Bending moment, lb-in.
S = Stress, psi
Z = Section modulus, in.³

They broke up the pellet traffic jam...



with Rockwood Ball Valves

A costly and recurrent problem in a large southern synthetic fibre mill was the jamming of polymer pellets as they came from supply hoppers. Source of the trouble was the tapered-throat design of the valves. Even with valves fully open, pellets piled up. In addition, this packing-in action caused severe abrasion on the valves. The problem was solved by replacement with Rockwood Ball Valves. Their *straight-through-opening* feature now permits pellet to flow smoothly . . . and the wear problem has been automatically eliminated because Rockwood valves offer no more resistance to flow than the pipeline itself.

What's more, after hundreds of openings and closings Rockwood Ball Valves still provide *positive leak-proof* shut-off means. A retainer spring, which *automatically compensates for pressure variations* keeps the seat snug against the ball and holds tight even under vacuum.

Thousands of Rockwood Ball Valves are giving efficient service and cutting costs throughout industry — in oil refineries, textile mills, paper, chemical and rubber plants.

There are types and sizes to meet every requirement in *your* plant. Write today for the illustrated folder on Rockwood Ball Valves. Tested and listed by Underwriters' Laboratories, Inc. Rockwood Sprinkler Division of the Gamewell Company. *A subsidiary of E. W. Bliss Company,* 825 Harlow St., Worcester 5, Mass. Distributors in principal industrial areas.

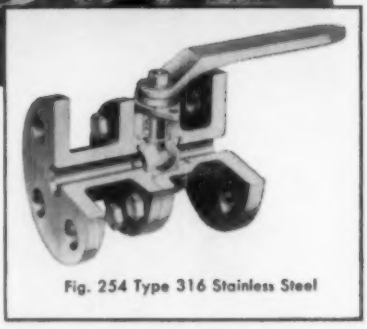
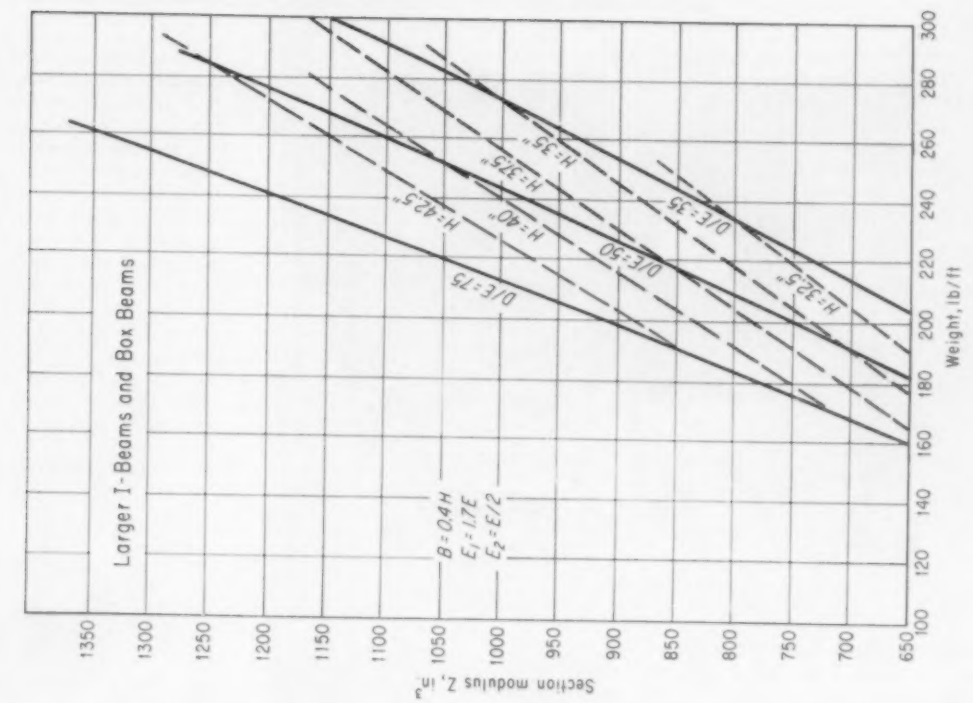


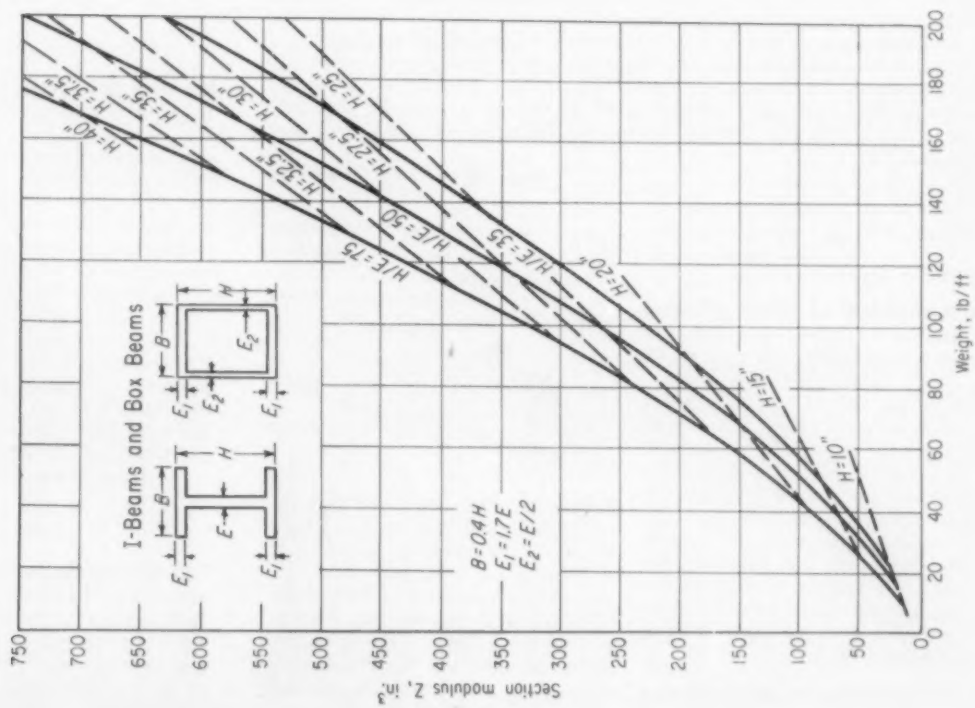
Fig. 254 Type 316 Stainless Steel

Rockwood Ball Valves are available in pipe sizes ⅜" through 16" in screwed ends 150 lb. and 300 lb. flanges. All internal parts are of Type 316 stainless steel with spring-compensated TEFLON* seats. Recommended for 600 p.s.i. working pressure and suitable for temperatures ranging from—100° F. to 400° F. All sizes are available with two retainer springs and two Teflon seats.

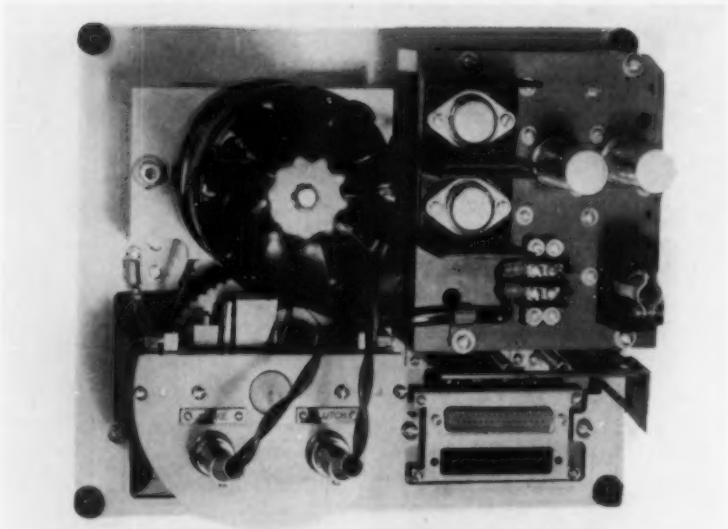
*DuPont Reg. T. M.

ROCKWOOD BALL VALVES


Larger I-Beams and Box Beams
B=0.4H
E1=1.7E
E2=E/2
H/E=75
H/E=50
H/E=35
H=42.5"
H=40"
H=37.5"
H=35"
H=32.5"
Section modulus Z, in.³
Weight, lb/ft


I-Beams and Box Beams
B=0.4H
E1=1.7E
E2=E/2
H/E=75
H/E=50
H/E=35
H=40"
H=37.5"
H=35"
H=32.5"
H=30"
H=27.5"
H=25"
H=20"
H=15"
H=10"
Section modulus Z, in.³
Weight, lb/ft

SIGNIFICANT COMPONENTS MATERIALS, PROCESSES

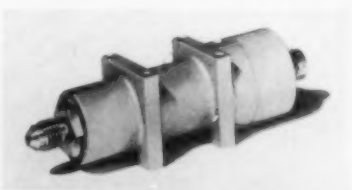


Modular block-type reader . . .
uses light-sensitive silicon cells to read up to eight characters in perforated tape simultaneously. Tape is driven from left to right by drive drum and pinch roller. Motor is coupled by timing belt to input gear of differential tape-drive assembly. Input gear is continuously driven by motor. Integral with tape-drive assembly is electronically controlled electromagnetic brake-and-clutch system. This permits block-by-block, or character-by-character tape advance. Sprocket-hole reading of only first and last characters of block provide information for block advance control. Power transistors operate brake and clutch magnets and are controlled by flip-flop circuit, which can be set to start or stop remotely or from front panel. Price depends on number of characters that must be read. Delivery, 90 days. **Ferranti Electric Inc, Electronics Div, 95 Madison Ave, Hempstead, NY.**

Circle 300 on Reader Service Card

Parts molded of filled silicone
are said to be suitable for continuous service at temperatures from —67 to 700 F. Units molded from the granular, thermosetting material are also reported to have dimensional stability and thermal-shock resistance in this temperature range. Molded parts are reported to demonstrate high arc resistance, over 400 sec, and dissipation factors as low as 0.002 at 10^6 cps. Conventional compression or transfer molding equipment and techniques can be used. Now available in unlimited production quantities. Complimentary evaluation sample is offered. **Dow Corning Corp, Midland, Mich.**

Circle 301 on Reader Service Card



Pressure measurement device
uses helical bourdon tube element coupled directly to rotary induction potentiometer in hydraulic and pneumatic systems. Can be spark-plug mounted to measure pressure in internal combustion engines. Units are oil-filled for additional damping and are said to be rated for 150% overpressure of rated pressure with no calibration shift; 250% of rated pressure specified burst. Available in ranges from 0-600 psia or psig to 0-20,000 psia or psig. Induction potentiometer transducers are said to offer long life, high accuracy and rapid response. Linearity is 0.5% of full ranges; hysteresis, 0.5% of full range; temperature error, 0.01% per deg F and vibration error (25 g, 50-2000 cps), 1% max. Unit with slighter higher response characteristics and lightweight unit are both furnished for 26 and 115 v, 400 or 60 cps operation. Said to have life span of 1 million cycles. Approximate base price for units, depending upon specifications, ranges from $250 to $300. Delivery, at present, 4 to 6 wk. **Servonic Instruments Inc, 640 Terminal Way, Costa Mesa, Calif.**

Circle 302 on Reader Service Card

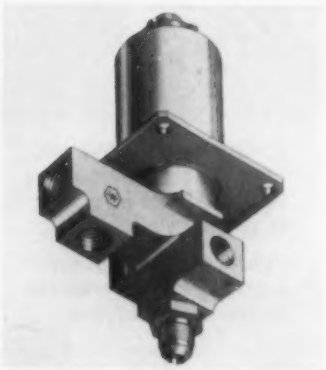
Vernier pressure regulator . . .
is for precision pressure calibration in non-flow pneumatic systems. Used in conjunction with coarse regulators or throttle valves, which establish approximate pressure within 5 psi. Variable-volume device has built-in balanced-pressure device said to make precise pressure regulation possible over range of 0.1 to 1000 psi, while maintaining actuating forces at low level. Desired pressure is established by increasing or decreasing volume of trapped air or gas. Can be used with dry air or nitrogen and is adaptable to other pressure media. Available from stock. Approximately $200, list. **Astromics, Div of Mitchell Camera Corp, 611 W Harvard St, Glendale, Calif.**

Circle 303 on Reader Service Card

Teflon film is cementable . . .
on one side with common adhesives. Prior to development of the new film, the only way to provide surface receptive to adhesives was by patented treatment with alkali metals in organic media. Film could also

be heat-sealed or heat-bonded to certain other materials. New-type film can also be used, without adhesives, to provide printable or pottable surface on spiral-wrapped, heat-sealed jacketing for wire and cable. Shares all properties of older TFE-fluorocarbon films at up to 400 F. Film is heat-sealable and heat-bondable to itself and to other materials. Now offered in developmental quantities at premium over standard film. Available in widths up to 30 in.; in gages from 1 to 40 mil. **E I du Pont de Nemours & Co, Wilmington 98, Del.**

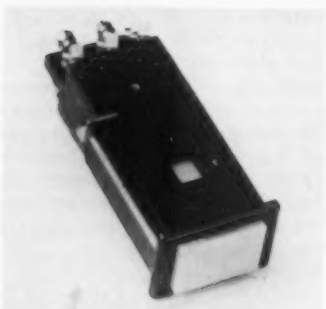
Circle 304 on Reader Service Card



Solenoid plunger and poppet

are directly coupled in three-way, cryogenic control valve specifically for use with helium, but usable with other gases. Total weight is 1.78 lb. Aluminum body incorporates optional inlet port connection. Insulation is not required with valve. Teflon O-ring and special seats are said to withstand temperatures from —320 to 165 F and shock and vibration. Choice of end fittings for flared or flareless tubing is available in sizes from ¼ to ½ in. **Weatherhead Co, 300 E 131st St, Cleveland 8.**

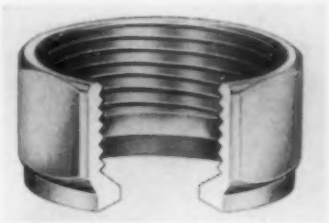
Circle 305 on Reader Service Card



Snap-action pushbutton switches . . .

are available in illuminated and nonilluminated versions and momentary or alternate-action configurations. One-piece unit eliminates external accessories. Mounts rigidly in most panel thicknesses. Available configurations include 1 or 2 SPDT switches with ratings of 5 amp at 220 v ac and 0.25 amp at 220 v dc. All switches are rated at 1 million operations. Prices range from $7.55 to $9 in unit quantities. **Truco Engineering Co, 289 Fairfield Ave, Hartford 6, Conn.**

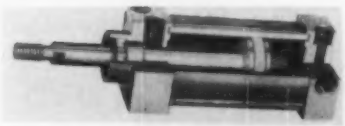
Circle 306 on Reader Service Card



Impact extrusion process . . .

is being used to fabricate metal products formerly manufactured by screw-machine and die-casting techniques. Compression nuts, in aluminum, brass, steel and stainless steel in all finishes, in full range of commercial sizes, are the first to be produced. **Jacobson Nut Mfg Corp, Box 177, Kenilworth, NJ.**

Circle 307 on Reader Service Card



1-in.-bore air cylinders . . .

employ self-lubricating Teflon piston seals and rod seal-wiper combinations to facilitate maintenance in cramped quarters. Cylinders are rated at 200 psi. Standard cylinder also incorporates hard chrome-plated piston rods, steel end caps and steel barrels with black oxide finish. Eight standard strokes ranging from ½ to 5 in. are available, with front flange, rear flange, trunnion, clevis or foot mountings. **Hydro-Line Mfg Co, Rockford, Ill.**

Circle 308 on Reader Service Card

Low-speed indicator . . .

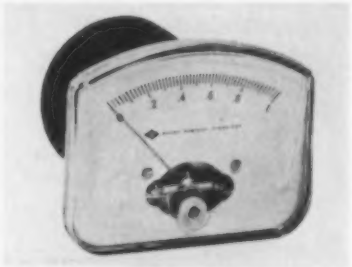
for speeds of 10 rpm and lower is said to have accuracy of better than 2% of full scale. Self-powered system uses low-torque dc generator with virtually unlimited brush life. The 4½ in. panel-mounted meter is shielded. Package consists of indicator, tachometer generator, 15 ft of connecting cable and mounting and coupling accessories. Price is $107. Delivery from stock. **Servo-Tek Products Co, 1086 Goffle Rd, Hawthorne, NJ.**

Circle 309 on Reader Service Card

Air-hardening tool steel . . .

has additive of minute, uniformly dispersed alloy sulfides, which imparts free-machining properties and self-lubricating action for die parts without sacrificing mechanical strength. Steel hardens between 1750 and 1775 F to give 63 to 65 Rockwell C. Hollow bar form is available in sizes from 2¼ to 16¼ in. OD and ¾ to 9¾ in. ID with wall thicknesses from ¾ to 4½ in. Surfaces are rough machined, leaving ⅛ in. for finishing. **Darwin & Milner Inc, 2222 Lakeside Ave, Cleveland 14.**

Circle 310 on Reader Service Card



Frequency-to-analog transducer . . .

with integral indicating meter is self-contained, lightweight package. Produces dc meter current that is directly proportional to input frequency or pulse rate. With standard 2½ in. D'Arsonval meter, accuracy is said to be ±1% of full scale; with larger instruments, accuracy of ±½% is available. Max frequency detected can be adjusted through 4:1 frequency range by means of built-in attenuator. Seven standard models cover audio range from 15 to 12,000 cps. Available with three standard input signal strengths of 2 w, 100 milliw and 0.1 microw. The 2-w drive is without amplification; 100 milliw and 0.1 microw signal strength units include integral transistor amplifier. Reported to be low in cost. **Pioneer Magnetics Inc, 850 Pico Blvd, Santa Monica, Calif.**

Circle 311 on Reader Service Card

Fingertip control valves . . .

with connections for ¼-in.-OD tube size are offered in brass and type 316 stainless steel. Can also be supplied with male pipe connection. Available in straight and angle pattern styles. Rated for 3000 psi pressure with 0.172 orifice dia. Forged-body valves are available with micro-regulating or nonregulating stems. Stems are machined from type 316 stainless steel. Teflon cylinder packing and panel mounting nuts are standard. **Whitey Research Tool Co, 5525 Marshall St, Oakland 8, Calif.**

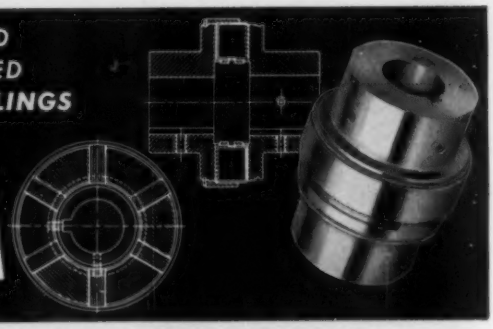
Circle 312 on Reader Service Card

continued on page 83

LOVEJOY Power Transmission Equipment

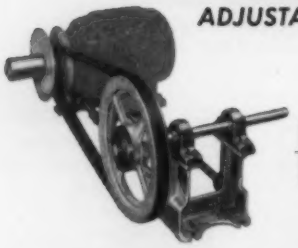
Job-Rated for the Particular Load to Give Maximum Performance on Your Job

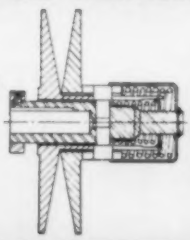
NON-LUBRICATED EASILY-ASSEMBLED FLEXIBLE COUPLINGS



Bores (max.) . . . . . 5/16" to 9½"
O.D. . . . . 5/8" to 21½"
Wt. . . . . ½ oz. to 1500 lb.
H.P. . . . . 1/20 to 3000
Torque (static) . . 1½ to 5100 ft.-lbs.

MAINTENANCE-FREE INSTANTLY-ADJUSTABLE VARIABLE SPEED PULLEYS



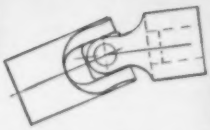


Bores (max.) . . . . . ½" to 1⅝"
O.D. . . . . 3" to 13⅝"
Belt Sizes . . . . . A to 2⅜ TW
Speed Ratios . . . . . 1-1 to 8-1
H.P. (1750 rpm.) . . . . ⅛ to 15

SHAFT MOUNTED, GEAR REDUCERS— ELIMINATE SUPPORTING STRUCTURES END ALIGNMENT PROBLEMS

18 Models From Stock
Speeds . . . . . 8 to 425 R.P.M.
H.P. . . . . Fractional to 120
Ratios . . Single 4.5:1 Nominal
Double 14.7:1 Nominal
Hollow . . . Shafts 1⅜ to 5⅛ in.

LIGHT-WEIGHT PRECISION-BUILT UNIVERSAL JOINTS



Bores . . . . . ⅛" to 2"
Hub Dia. . . . . ½" to 4"
Static Torque 340 to 130700 in.-lbs.
H.P. (100 rpm.) . . . . . ½ to 207

Get Lovejoy performance for your equipment. Request full information now.

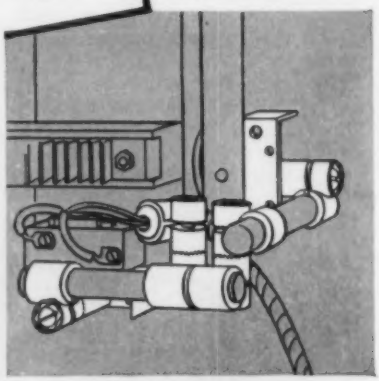
LOVEJOY FLEXIBLE COUPLING CO.

4841 WEST LAKE STREET • CHICAGO 44, ILLINOIS

82 CIRCLE 82 ON READER SERVICE CARD

NEW! for industry

Rotocon TRADEMARK ASSEMBLERS



Build high strength rod, tube, and pipe structures in minutes . . . for permanent or temporary use.

Save costly design and machining time on precision assemblies and fixtures.

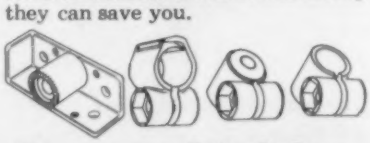
Speed and ease of assembly, superior strength, and infinite adjustability! **Rotocon** assemblers are ideal for hundreds of permanent or temporary applications with metal rods, tubes, and pipe.

Joint and grip

Toothed faces of paired assemblers form rigid joints at every 10-degree increment, including right angles. Tight, all-around grip never burrs, scores, or distorts round stock—won't squeeze tubing out of shape. Only a screwdriver or a coin is needed to tighten the screw in the nesting nut.

Snap-clamp snaps on over existing structures and fittings. No need to take apart existing assemblies to make additions.

Sample offer—Your request on your letterhead will bring you a sample kit of **Rotocon** assemblers, free and postpaid. You have to see them, hold them in your hand, and experiment with them in your own application situations to discover the time and money they can save you.



Rotocon Division
UNISTRUT PRODUCTS COMPANY
935 West Washington Blvd., Chicago 7, Ill.

CIRCLE 204 ON READER SERVICE CARD

12- and 24-hr clocks . . .

incorporate concept of mechanical transfer of numbers by planetary-gear drive. Instantaneous snap-over of numbers is accomplished by nylon cam and roller compensating device, which moves planetary gear. Digits are in full view at read line at all times. Timing motors of various voltages and frequencies can be used. Preset of hours and minutes is manual. Set knob on side is geared to seconds drum with step-up ratio of 8:1. Numerals are ⅜ in. high, white on black for hour and minute nylon drums, and either black or red on white for graduations and numerals on second wheel. Mounting dimensions are 2⅞ x 2⅜ in.; depth is 4 in. max. 12-hr model is $75 with about 3-wk delivery; 24-hr model is $155, with 6- to 8-wk delivery. **Haydon Instrument Co, 165 W Liberty St, Waterbury 20, Conn.**

Circle 313 on Reader Service Card

Multiple programing sequences . . .

are provided by scanner system combining photoelectric scanner-relay and adjustable electronic timer. Sensitivity ranges are from 2 in. to 18 ft with adjustable time-delay ranges from 1.5 to 30 sec. Scanning can be direct or by reflected light. Two SPDT relays have pull-in, hold-in and drop-out characteristics that are determined by way unit is connected. Relay-contact ratings are 8 amp noninductive at 125 v ac. System is housed in NEMA No. 1 case. Can be connected to any 100-130 v, 60 cps line. **Farmer Electric Products Co Inc, 2300 Washington St, Newton Lower Falls, Mass.**

Circle 314 on Reader Service Card

Aluminum oxide insulated wire . . .

and strip are for high-temperature applications. Aluminum oxide insulation with melting point of 3600 F has voltage breakdown of about 30 to 40 v per micron mm (0.000,04 in.), is inorganic, will resist nuclear and neutron radiation, gamma rays, is chemically inert and withstands temperatures below zero and higher than most conductive metals. Aluminum oxide film insulation is available from continuous anodic process. Film is anchored in pores

continued on page 85

Productivity 30% up
Space 30% down

HAMILTON
deluxe
Auto-Shift
drafting tables

"Increased production 30%" . . . "Saved 30% floor space" . . . Reports like these from firms using Hamilton drafting furniture indicate the end benefits of the new Hamilton Auto-Shift. **Wide range of individual board adjustments** reduces fatigue and creates exceptional efficiency, higher work quality. Every inch of the drawing surface within easy reach—seated or standing.

Scientifically seasoned drawing surface. Front-to-back filing in full-width drawers. **Concealed mechanism** controls height; slope quickly adjustable to individual needs. Front table, basic table, and rear reference desk style-matched. Many more functional and style features. **Write today for complete data.**

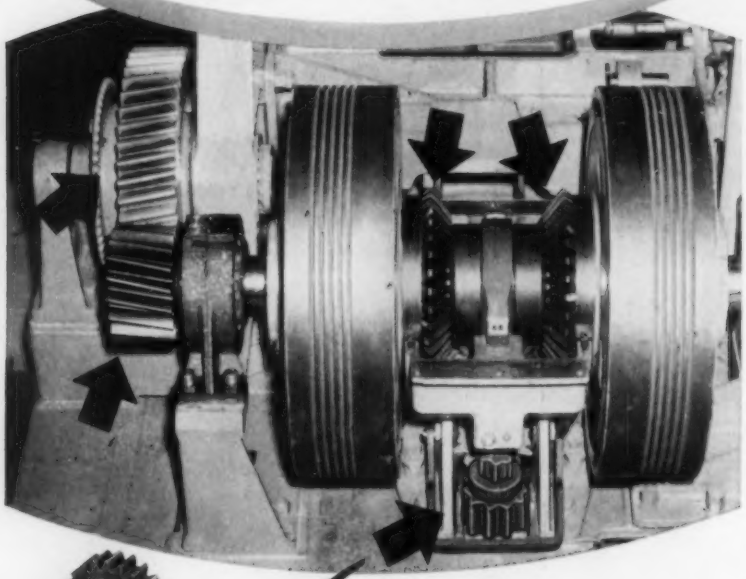
Hamilton
PROFESSIONAL AND SCIENTIFIC FURNITURE

new dimensions in time and space efficiency for: physicians; dentists; industrial, hospital, school laboratories; draftsmen; printers; libraries; home laundries.

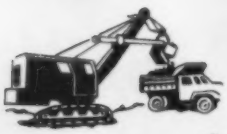
Hamilton Manufacturing Company, Two Rivers, Wisconsin

CIRCLE 83 ON READER SERVICE CARD

Do You have requirements for "Special Gears?"



✓ CHECK with FAIRFIELD!



"Fairfield has furnished us with bevel and spur gears for many years and we are highly satisfied with their product," states one of America's best known makers of shovels, cranes, and draglines in referring to the above picture. Each gear (*see arrows*) is precison produced to match this builder's specifications for *plus value* quality.

Making gears to meet exacting specifications is our business. The special or unusual requirements you have for design, size, finish, tolerances, materials, and heat treatment are often "standard" at FAIRFIELD. Here, every facility needed is available for production of fine gears EFFICIENTLY, ECONOMICALLY. *LARGE or SMALL, your inquiry will receive prompt attention.* CALL or WRITE.

FAIRFIELD MANUFACTURING CO., INC.
2305 South Concord Road • Lafayette, Indiana
TELEPHONE: SHerwood 2-7353

Gears and Differentials for FINE GEARS *Made to Order for:*

TRACTORS • HEAVY DUTY TRUCKS • AGRICULTURAL MACHINERY • POWER SHOVELS AND CRANES
MINING MACHINES • ROAD GRADERS • BUSES • STREET SWEEPERS • INDUSTRIAL LIFT TRUCKS

No. 19 of a series

Eastman 910 Adhesive solves another production bottleneck

Templet Industries, Inc., Brooklyn, N.Y., produce steel-rule stamping dies that can cut through 1-inch steel plate.

Neoprene ejector springs, conforming to the shape of the die, are mounted alongside the steel rules on the base plates. Bringing the dies together compresses the neoprene. When the dies are released, the neoprene expands to its original thickness, ejecting the stamped part and the scrap.

Needed was a simple method of securely bonding the neoprene to the metal and wooden base plates. The answer? Fast-setting, high-strength Eastman 910 Adhesive. The bond it makes holds for the life of the dies, which can run to more than 250,000 stampings.

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is used as it comes. No mixing, no heating. Simply spread the adhesive into a thin film between two surfaces. Light manual pressure triggers setting. With most materials strong bonds are made within minutes.

What production or design problems can this unique adhesive solve for you?

Bonds Almost Instantly with Contact Pressure
No Heat...
No Catalyst...

For a trial quantity (⅓-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9111 Irvin Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. P-11, Kingsport, Tenn. (Not for drug use)
See Sweet's 1960 Prod. Des. File, 7/E

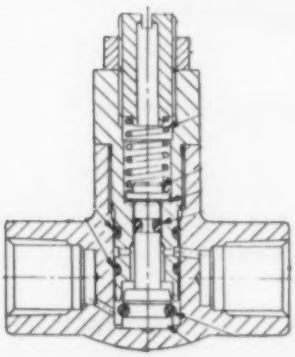
of base metal and is flexible and uniform, does not craze or peel, exhibits excellent dielectric properties to 3600 F. Where aluminum wire is used, space and weight savings are significant. Wire and strip is available in most gages and sizes. **Permaluster Inc, 2012 W Burbank Blvd, Burbank, Calif.**

Circle 315 on Reader Service Card

Fuse filament is vacuum-sealed

instead of being sealed with dry air or inert gas. When fuse breaks circuit, there is no arc path to support further electrical flow. In operation, fuse is also an indicator because of flowing effect of wire within vacuum. Ratings are in fractional and 25-250 milliamp. **Thermal Controls Inc, 41 River Rd, N Arlington, NJ.**

Circle 316 on Reader Service Card



Pressure-gage protector . . .

for gas service in pressure range of 30 to 150, 150 to 500 and 500 to 1000 psig handles inlet pressures up to 3000 psig at from −10 to 200 F. Three springs are included with each unit to cover these ranges. Can be factory preset within these ranges at extra cost. Inlet and outlet connections are ¼ in. NPT female, permitting gage to be threaded directly to the protector. Adjustment to set protection point can be made without removing unit from system. Once set, protector remains fixed and stops flow to gage when pressure protection point is reached. Reset is automatic when pressure drops below protection point. Protector is 1⅞ in. long and weighs 5.25 oz. **Hoke Inc, 1 Tenakill Park, Cresskill, NJ.**

Circle 317 on Reader Service Card

Automatic-drain air filter . . .

is self-cleaning and requires no manual draining. Centrifugal action spins out heavier-than-air solids. Cartridge of two monel screens filters air. Cartridge is removable for cleaning. Momentary differ-

continued on page 87

One word explains the popularity of these switches...

Dependability!

Denison LOXSWITCH Limit Switches operate with the dependability of Old Faithful. Oil- and dust-tight features, superior electrical characteristics and mechanical design result in three to five times longer life than comparable switches.

L100W HEAVY DUTY LIMIT SWITCH

- 45 CIRCUIT ARRANGEMENTS.
- LONGEST CONTACT LIFE due to lowest impact of 2.5 grams and minimum "bounce".
- WATER-, DUST- AND OIL-TIGHT, NEMA 12.
- ONLY FOUR MOVING PARTS. Longer life, easier to maintain.
- 70° SAFETY OVERTRAVEL without use of extra springs or cams.
- OVER 150 LEVER STYLES.

MODEL M PRECISION LIMIT SWITCH

- LONG MECHANICAL LIFE nylon latch mechanism.
- 600 VOLT INDUSTRIAL CONTROL RATING.
- COMPLETELY ISOLATED CIRCUITS.
- 6° TRIP DIFFERENTIAL, 50° overtravel in both directions.
- PRECISION REPEATABILITY ± .001".
- WATER-, OIL-, DUST-TIGHT – NEMA 12.
- FULLY INTERCHANGEABLE with thousands of existing layouts.

BOTH MODELS AVAILABLE WITH PLUG-IN CONVENIENCE

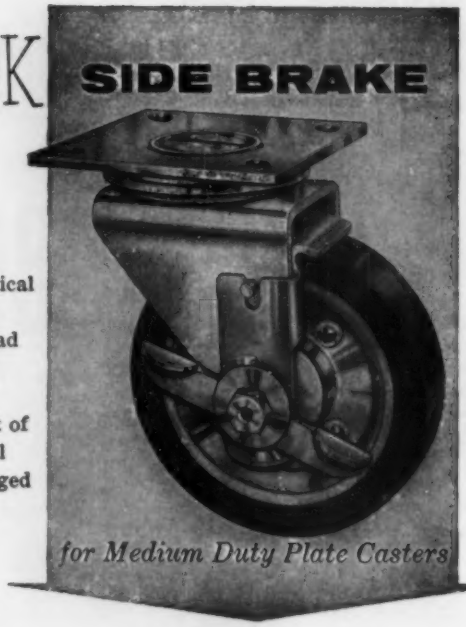
Write for literature describing our complete line.

Address R. B. DENISON MFG. CO., 386 Broadway, Bedford, Ohio

DENISON LOXSWITCH

*Wire with **LOXSWITCH** and you wire for good!*

NEW J&J VERTILOK



To provide greater locking strength, the J & J "Vertilok" side brake features a vertical cam action and a specially formed brake shoe which contacts the maximum tire tread area. A slight press of the toe and the wheel is securely locked . . . or completely released. Provision is made for adjustment of the braking action to compensate for wheel or tire wear. Simplicity of design and rugged construction assure long, trouble-free life.

Suitable for all 4" to 6" rubber wheels, with hard or soft tread; steel disc replaceable tread wheels, 4", 5" and 6" diameter; also medium casters with standard 4" x 4" top plate.

Sold Through Quality Dealers

Jarvis J&J Jarvis, Inc.
PALMER, MASSACHUSETTS

Sales Representatives In Leading Cities Throughout the Country

IN CANADA: Jarvis & Jarvis of Canada, 1744 William St., Montreal, Que.

CIRCLE 206 ON READER SERVICE CARD

ALLENAIR
Cylinders

NEW 88-PAGE CATALOG AVAILABLE
Write Before Next Tuesday!

ALLENAIR CORP., 255 East 2nd St., Mineola, N. Y. PEG-11

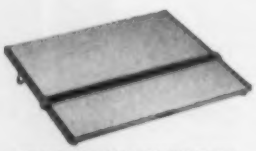
Name.....

Company.....

Address.....

City.....Zone.....State.....

MAYLINE



PROFESSIONAL DRAWING KIT

Christmas Gift Suggestions!

For those personal gifts at Christmastime may we suggest Mayline drafting equipment and supplies.

The Professional Drawing Kit and Carrying Case is an ideal combination.

For complete information on all products see your local dealer today!

GEM PEDESTAL TABLE

MASTER TABLE

Mayline Co., Inc.
607 No. Commerce St.
Sheboygan, Wisconsin

MAYLINE

MAYLINE

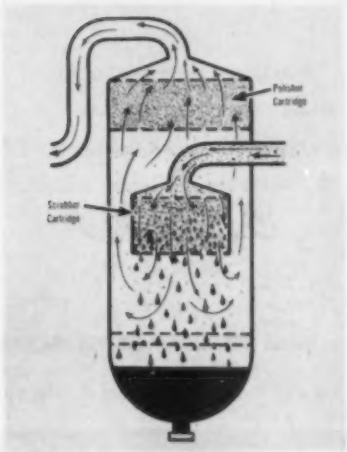
MAYLINE

CIRCLE 86 ON READER SERVICE CARD

CIRCLE 207 ON READER SERVICE CARD

ential pressures above and below neoprene diaphragm seal poppet valve with snap-action against upper and lower seats. During travel between poppet seats, air blows out accumulated moisture and solid particles that have previously drained into sediment bowl. Lower end of unit is threaded ⅛-in. male pipe for attachment of pipe or hose to drain away condensate. Available in ¼, ⅜ and ½ in. full area pipe sizes. Priced from $16.75 to $27.75. Shipment from stock. **OEM Equipment, 19560 Center Ridge Rd, Cleveland 16.**

Circle 318 on Reader Service Card



Compressed-air filters . . .

for use with pneumatic instruments and controls and air-operated equipment of all kinds employ coalescent action. Max flow rates range from 20 to 200 cfm. Pipe sizes range from ¼ to 2 in. Filters use down-flow wet-cartridge filtering. Incoming air passes downward through scrubber cartridge that removes close to 98% of all mist and fog of oil and water, as well as solid particles. It then flows through polisher cartridge that removes remaining liquid particles. Both cartridges are disposable. One standard size fits all filters. **King Engineering Corp, PO box 735, Ann Arbor, Mich.**

Circle 319 on Reader Service Card

Incandescent indicator light

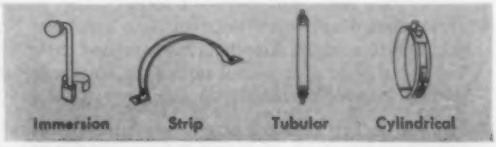
is miniature unit with built-in transistor flip-flop that operates directly from low voltage supply sources and low logic voltage levels. Transistor flip-flop, housed in black anodized aluminum case, ½ in. dia x 1⅜ in. long, has set and reset for switching indicator light on and off and will switch 2 microsec pulse with input of 1 milliamp. Indicators are supplied for 5, 6, 8, 10, 12 or 14 v, positive or negative, and with supply current drain of 20 or 45

continued on page 89

WATLOW'S
FIREROD®
CARTRIDGE HEATER
HAS ESTABLISHED
A NEW CONCEPT
IN HEAT RANGE...
HEATER LIFE

Watlow's FIREROD combines in one unit the best of all those factors most often sought in an electric cartridge unit: it's the *HOTTEST* heater going (gives you 5 times more heat than any standard unit, yet offers an amazing *heat range* up to 1500°F and higher) . . . the *LONGEST LASTING* cartridge operating at *any* temperature (will out-live, out-perform 5 to 10 ordinary heating units) . . . and the most *DESIGN-WISE* cartridge available today (the *same* heat you'd get in a standard unit, in 1/5 the space).

So . . . whether you're looking for high concentration of heat or longer-lasting cartridge heaters – you'll want to learn more about the FIREROD. WRITE for FIREROD BULLETIN #367.



WATLOW
ELECTRIC MANUFACTURING CO.
1392 Ferguson Avenue
St. Louis 14, Mo.

Selas saves thousands of maintenance hours on combustion controls

Reevecote synthetic diaphragm goes into place on pressure governor section of Selas Combustion Controller. Reevecote has more than doubled the service life of diaphragms on these units.

with REEVECOTE SYNTHETIC DIAPHRAGMS

By switching from leather to synthetic diaphragms of Reevecote in its Combustion Controllers, the Selas Corporation of America saved thousands of maintenance hours. They also improved the accuracy of these units.

Problem: Originally, leather diaphragms were used in the mixing valve and in the pressure governor of the compressor. These two diaphragms required the most frequent maintenance of all parts in the unit. The leather had a tendency to dry out, stiffen and crack. Accuracy was impaired. The leather required frequent oilings and service life was limited to less than 12 months.

Solution: Selas switched to synthetic diaphragms of Reevecote 7134 and 7028, made by the Vulcan Rubber Products Division of Reeves Brothers, Inc. After 2 years of service, diaphragm maintenance has been practically nil. The Reevecote diaphragms retained their flexibility, did not dry out, required no oiling. Accuracy improved and thousands of maintenance hours were saved.

If *your* design calls for any type of diaphragm – any use of coated fabrics – choose from over 200 styles of Reevecote – the most complete line of synthetic coated fabrics for industry. Write for new Reevecote Catalog.

REEVES VULCAN

Reeves Brothers, Inc., Vulcan Rubber Products Division
1071 Avenue of the Americas · New York 18, New York

88 CIRCLE 88 ON READER SERVICE CARD

AGMA

DYNACO MASTER CATALOG F-128

128 PAGES!

LISTS OVER 50,000 DYNACO COMPONENTS AVAILABLE FROM STOCK!

Gears • Shafts • Differentials

Transmission • Speed Reducers & Gearheads

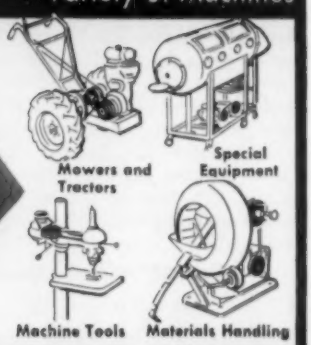
DYNAMIC
GEAR CO. INC.
AMITYVILLE, NEW YORK

CIRCLE 208 ON READER SERVICE CARD

SPEED SELECTOR

VARIABLE PITCH SHEAVES

Control Speeds on Variety of Machines



Wide Speed Range! Low Cost Sheaves

Speed Selector Sheaves can give your machines or equipment extra wide-range speed control on fixed centers. Efficient, rugged, simple to use — low in cost! Write for Illustrated Bulletin.

CATALOG FREE! WRITE TODAY

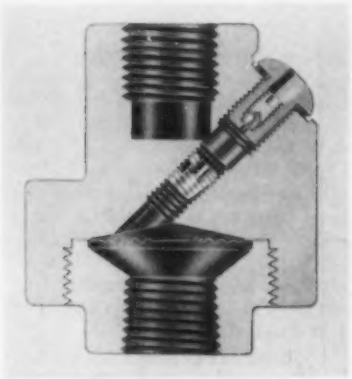
SPEED SELECTOR INC.

P.O. BOX 312-F • CHAGRIN FALLS, OHIO

CIRCLE 209 ON READER SERVICE CARD

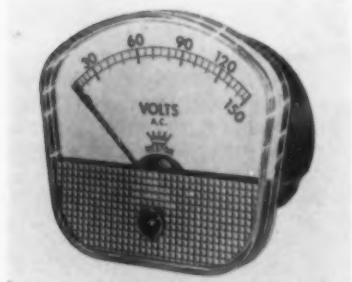
milliamp. Lenses are offered in choice of colors. C & K Components Inc, 101-103 Morse St, Newton 58, Mass.

Circle 320 on Reader Service Card



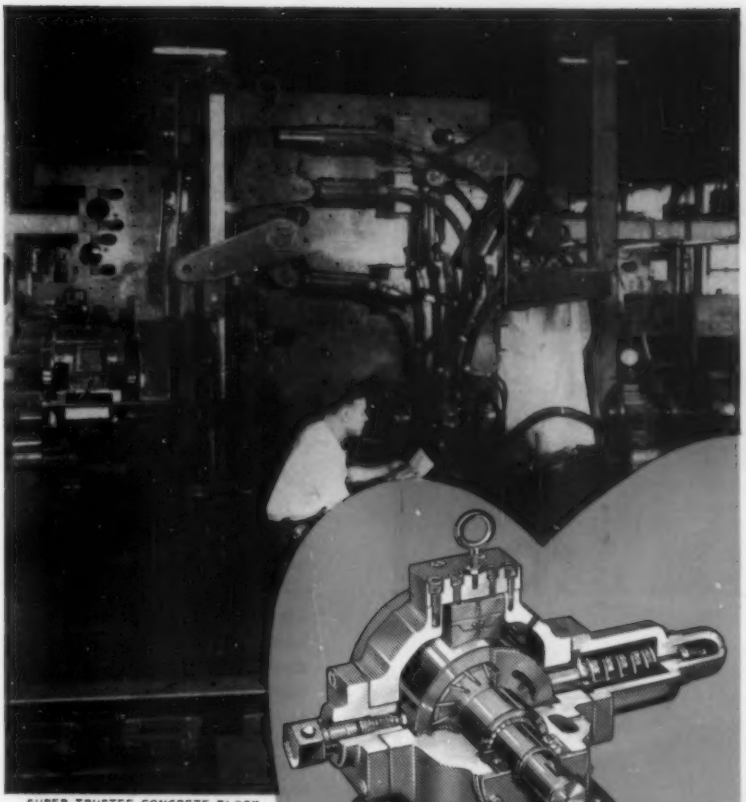
Pressure-gage accessories . . . protect gages against pulsating pressures or corrosive chemicals. Both units are similar in basic design. Both have stainless steel or neoprene diaphragm that separates measured fluid from measuring element. Space above diaphragm is filled with viscous, nonfreezing liquid that transmits measured pressure to gage element. For pulsation dampening, there is adjustable restriction in passage from diaphragm top to gage. Design permits access to passage at side of unit. Gages equipped with dampener can be used with fluid temperatures between 50 and 100 F without temperature correction. Both units screw on standard male threads of gage. US Gauge, Div of American Machine & Metals Inc, Sellersville, Penna.

Circle 321 on Reader Service Card



Low-cost ac panel meter . . . has accuracy of ±2% of full scale value. Employs movable iron-vane mechanism and is available as voltmeters, ammeters and milliammeters. Enclosed in crown-profiled case, equipped with plastic cover and molded bakelite base. Top and sides of cover are clear. Has lance-type pointer and black-on-white 2.25 in. scale covering

continued on page 90



SUPER TRUSTEE CONCRETE BLOCK MACHINE BUILT BY THE GENE OLSEN CORP., ADRIAN, MICHIGAN

This dependable hydraulic heart

The heart of this 1100 blocks per hour concrete block machine is a RACINE MODEL 8R PUMP

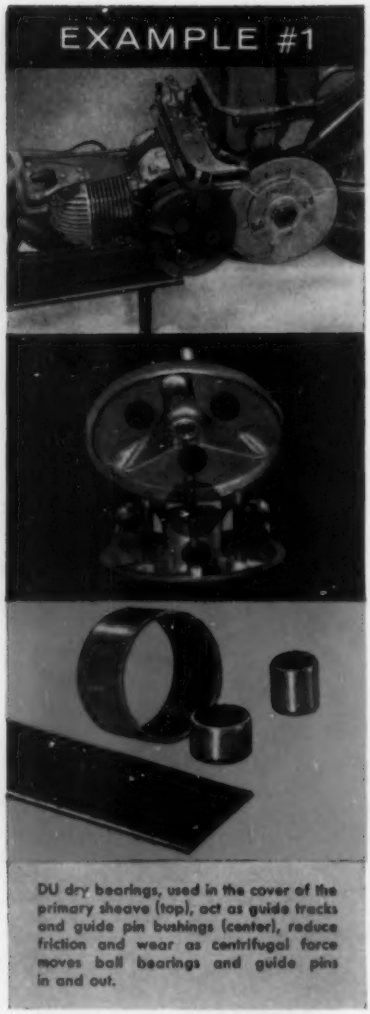
REDUCES UPKEEP AND DOWN-TIME BY AS MUCH AS 80%

"RACINE HYDRAULIC EQUIPMENT is the *heart* of our concrete block machines," says C. S. DeLamater, sales manager for The Gene Olsen Corp., another satisfied user of RACINE PUMPS and VALVES exclusively since 1949. Besides the tremendous savings in operating hydraulically-designed concrete block machinery, the firm emphasizes the advantage of simplified control of oil circulation in RACINE VARIABLE VOLUME PUMPS. They pump *only* the oil required to do the job — no waste of pressure oil — no heating. Thus through lower horsepower, operation economies are enjoyed.

RACINE

Racine Hydraulics & Machinery, Inc.
RACINE, WISCONSIN
HYDRAULICS DIVISION

CIRCLE 89 ON READER SERVICE CARD



DU dry bearings, used in the cover of the primary sheave (top), act as guide tracks and guide pin bushings (center), reduce friction and wear as centrifugal force moves ball bearings and guide pins in and out.

NEW GLACIER DU* DRY BEARINGS

greatly improve transmission design of Harley-Davidson "Topper"

Used at vital locations in the transmission assembly, DU dry bearings reduce friction and wear to the absolute minimum on the latest addition to Harley-Davidson's fine motor scooter line. DU dry bearings solve another problem, too—the accumulation of dirt and grime in the transmission lubrication. DU material requires no lubrication whatsoever, and will last many times longer than other dry bearings.

DU metal is an ideal bearing material. It withstands much higher velocities, runs much cooler at lower speeds than other unlubricated bearings . . . has a compressive strength of 51,000 p.s.i. DU metal is applied without the need for temperature-limiting adhesives . . . will withstand from −328°F to +536°F.

Apply DU material to appliances, automobiles, aircraft, farm and industrial machinery, office equipment. Standard bushings and thrust washers stocked for ⅜″ to 2″ shafts; strip available for special fabrication. Find out more from your bearing manufacturer, or write for engineering catalog DU-458. **Special Products Dept.**, United States Gasket Company, Plastics Division of Garlock Inc., Camden 1, New Jersey.

GARLOCK

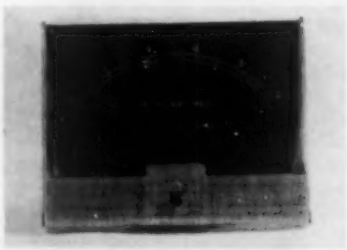
*Trademark, Glacier Metal Company Ltd.

90° arc. When mounted behind panel, single external bulb provides illumination for use in dimly lighted areas. **Daystrom Inc, Weston Instruments Div, 614 Frelinghuysen Ave, Newark 12, NJ.**

Circle 322 on Reader Service Card

High-performance switch . . . is sealed against dust, oil or moisture. Case-halves are permanently sealed together and flexible silicone boot seals clearance between case and operating button. Can be furnished with plain button, hinged lever actuator or hinged roller-lever actuator. Switches are UL- and CSA-listed for SPDT operation at 15 amp, 125/250 v ac, ¾ hp, 125 v ac or 1½ hp, 250 v ac. Quick-connect terminals are standard. **Unimax Switch Div, W L Maxson Corp, Ives Rd, Wallingford, Conn.**

Circle 323 on Reader Service Card



Acrylic plastic front meter . . . has wide-angle extended scale. Available in standard milliammeter, ammeter and voltmeter ranges with accuracy of 1% of full scale. Also incorporates taut band suspension design, which eliminates friction by eliminating pivots, jewels and hairsprings. **Hickok Electrical Instrument Co, 10609 Dupont Ave, Cleveland 8.**

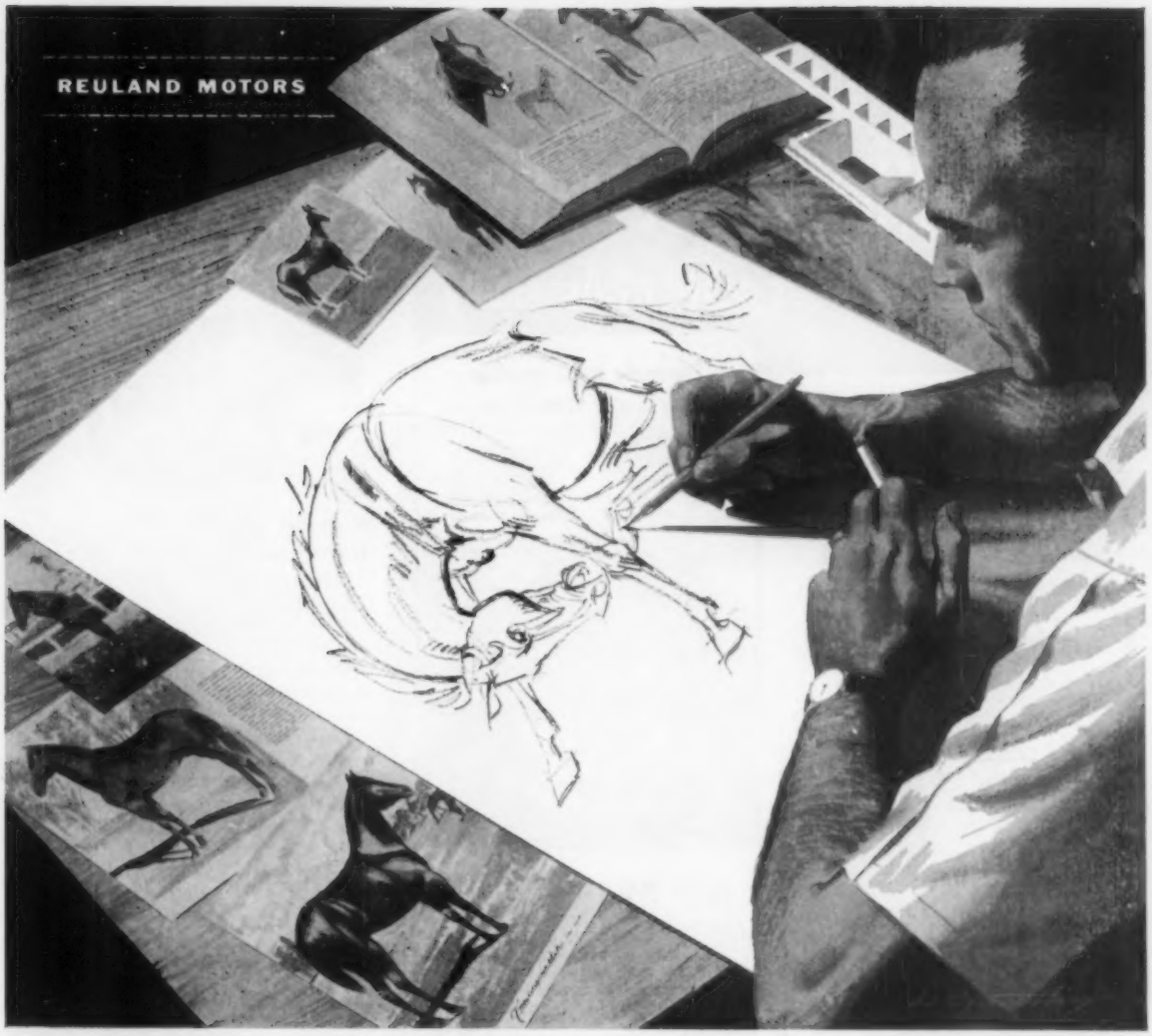
Circle 324 on Reader Service Card

Environmental connector . . . is circular unit with resilient silicone rubber inserts that seal throughout extremes of temperature and pressure. Crimp-style contacts are removable, basically designed to performance requirements of MIL-C-26636. Presently available in 55 contacts with strain relief clamp hardware, if desired. Connector is said to meet environmental requirements of MIL-C-26500. **Methode Mfg Corp, 7447 W Wilson Ave, Chicago 31.**

Circle 325 on Reader Service Card

Rotary bin activator . . . applies vibrating motion directly to material and not to bin walls containing material. Hermetically sealed and said to require no maintenance, it is applicable to

continued on page 92



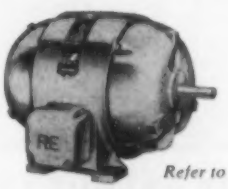
"Molded Horsepower" to fit your equipment

...no longer must you "make something do!"

Just as a famous artist molds each illustration to his need... so, too, can you now have an electric motor exactly tailored to the needs of your equipment. Not just another motor that can be "made to fit" but a complete power package with all desired electrical and mechanical characteristics built right in.

Reuland "Molded Horsepower" is a natural outgrowth of the famous "Xpandable" design idea originated by Reuland many years ago. Through this technique, motors, brakes, fluid couplings, gear reducers and similar devices are available in an almost unlimited number of combinations... all standard units assembled within a single frame and tailored to your specific application.

Only Reuland offers such a wide background of experience in tailored power packages. No wonder Reuland is also the "number one" supplier to many of the top original equipment manufacturers in America!



Our new 8-page catalog, No. GS8-30-0, will come in handy. Sent complete with prices and engineering drawings on request.

Refer to Sweet's Product Design, Section 5-a

MODERN POWER FOR MODERN-DAY PRODUCTS

... all in lightweight, cool-running aluminum frames!

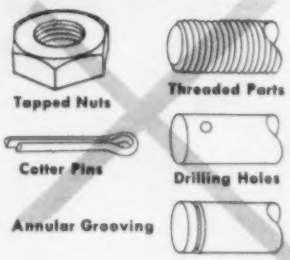
REULAND MOTORS

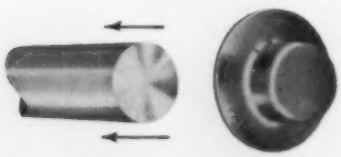
REULAND ELECTRIC COMPANY
WESTERN DIVISION: *Alhambra, Calif.*
EASTERN DIVISION: *Howell, Mich.*
Distributors in all principal cities

Investigate this wide choice of PUSHNUT® FASTENERS to speed up and cut costs of Assembly

- **SIMPLY PUSH ON** plain rods, axles, studs or pins.
- Easy, fast assembly with manual tools or high speed air hammers.
- Tight, vibration-proof grip.

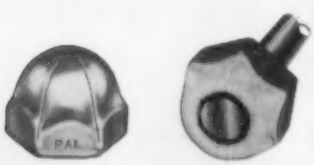
Eliminate these costlier parts and operations





WASHER CAP TYPE

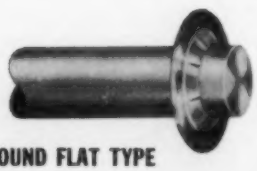
Style PW. Covers rod ends with smooth, rugged cap. Made of one-piece, heavy gauge spring steel with powerful gripping action. Always align perfectly. Various designs and finishes in sizes for 3/16", 1/4", 5/16", 3/8", 7/16" and 1/2" dia. unthreaded rod, wire and studs.



Style PC Style PK

ACORN TYPE

Pleasing, decorative appearance and strong spring grip for fastening or covering ends of rods, studs, pins, etc. Closed and open end styles. Sizes from .120" to .312" dia.



ROUND FLAT TYPE

Style PS. Low-cost, space-saving spring steel retainers push on plain rod or axle, providing strong, firm retention of parts, seated or unseated. eliminate notching, grooving, drilling and cotter pins. Sizes for 1/16", 3/32", 1/8", 3/16", 1/4", 5/16", 3/8" and 1/2" dia. rod.

Style PV. Light duty retainer with flexible spring gripping teeth for easy assembly with fingers. For rod dia. 1/4", 5/16", 3/8" and 7/16".

ARCHED RECTANGULAR TYPE

Style PH. Push on unthreaded studs to assure tight, vibration-proof assembly of ornaments, medallions, nameplates and other parts. Grip tight on hard chrome studs. Sizes for 1/16", 5/64", 3/32", 1/8" and 5/16" dia. studs.

Write for Free Samples and Data, stating type, size and application.

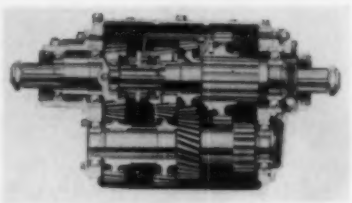
PALNUT®

THE PALNUT COMPANY
DIVISION OF UNITED-CARR FASTENER CORPORATION
65 Glen Road, Mountainside, N. J.
Canada: P. L. Robertson Mfg. Co., Ltd., Milton, Ont.

LOCK NUTS and FASTENERS

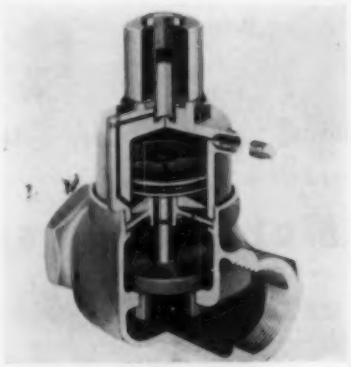
any bin, regardless of size, shape or material of construction. Noiseless activator can be moved vertically during operation to activate material throughout bin, regardless of its length, so that vibrating impulses reach all parts of bin interior. **Vibra Screw Feeders Inc, 156 Huron Ave, Clifton, NJ.**

Circle 326 on Reader Service Card



4-speed auxiliary transmissions . . . for medium- and heavy-duty trucks and tractors offer overdrive, direct, low and low-low in compact 375-lb unit. Provide gear ratios of 0.85 for overdrive; 1, direct; 1.24, low; and 2.22 low-low. One model is for use with engines producing about 500 to 600 ft-lb of torque. Use of high-capacity bearings permit second unit to be used with engines in 600 to 700 ft-lb torque class. **Fuller Mfg Co, Kalamazoo, Mich.**

Circle 327 on Reader Service Card



Remote-control valves . . . automate opening, closing and timing of pipe lines. Used in conjunction with cam switch, timing switch or sequence timer, valves eliminate human error in scheduling flow of water or other liquids. Rated for 150 psi water at 150 F. Available for 1 through 6 in. pipe. Model 1825 valves incorporate solenoid and are connected by wiring to timing device. Model 25 valves are hydraulically actuated through plastic or copper tubing, which links them with hydraulic controller. Both types close automatically in event of electrical or hydraulic power failure. **Febco Inc, 1993 Blake Ave, Los Angeles 39.**

Circle 328 on Reader Service Card

Heavy-duty bin vibrator . . . regulates and maintains steady flow of materials by double-impact system in which vibrator hammer strikes anvil at both top and bottom of stroke imparting, at 60 cps, the equivalent of 7200 sledge-hammer blows per min. against bin wall. Semi-resilient impact elements cushion impact sufficiently to result in semi-noiseless operation. Installs on chutes, hoppers and bins with walls to thickness of ¼ in. and up to 50-ton capacity. Units are enclosed and operate direct from ac line. **Eriez Mfg Co, Erie 6, Penna.**

Circle 329 on Reader Service Card

High-volume whiteprinter . . . processes any dry diazo sensitized material up to 19 in. wide at speeds up to 60 ft per min. Said to be capable of turning out up to 2000 letter-sized copies per hr. Measures 28½ x 33¼ in. wide without feedboard. Net weight is 420 lb. Operates on 220 v ac, 60 cps, single-phase and is UL-approved. **Ozalid Div of General Aniline and Film Corp, 64 Corliss Lane, Johnson City, NY.**

Circle 330 on Reader Service Card

Vertical blueprint file . . . is 32 x 36 in. deep and 60 in. high. Direct clamp-type plan holders, with T-tops, glide into and out of rigid channel tracks. In filing position, plan holders are fully enclosed. Hold up to 1200 individual sheets. **Momar Industries, 4176 W Montrose Ave, Chicago 31.**

Circle 331 on Reader Service Card

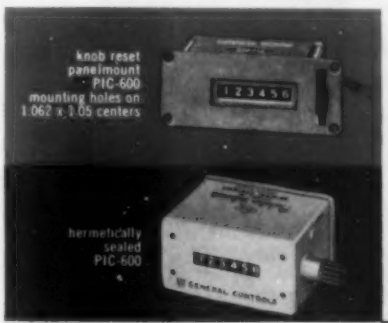
Servo development kit . . . in Size A consists of permanently packaged group of standardized servomechanism components from which a wide range of mechanisms and gear trains can be assembled. Servomechanisms with gear ratios as large as 78,125:1 can be assembled. Anti-backlash gears, slip clutches and infinitely adjustable limit stops are included. Material and design requirements of MIL-E-5400C are said to be fulfilled. Constructed of anodized aluminum alloy and corrosion-resistant steel. Ballbearings are ABEC Class 7 corrosion-resistant steel. Kit is $690. **Precision Mechanisms Corp, 577 Newbridge Ave, East Meadow, NY.**

Circle 332 on Reader Service Card

123 COUNTERS FOR ELECTRONICS AND INSTRUMENTATION

PIC-600 quiet electric counter offers great advantage for low level DC circuits - draws only .14 amperes from 30-volt transistor circuit.

QUIET OPERATION Efficient magnetic circuit and balanced mechanical action result in smoother operation with reduced noise



RECTIFIED FOR AC Eliminates AC hum — gives DC operating reliability from 25/40/50/60 cycles.

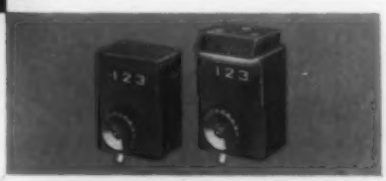
50 MILLION COUNT LIFE On life tests at 1000 cpm pass 100 million counts.

1000 COUNTS PER MINUTE Much higher speeds with suitable actuating impulses.

BALANCED ARMATURE Smooth, quiet operation and low friction in any position.

Also available to count dozens, coins, pairs, quads, etc.

TURNS COUNTER FOR POTENTIOMETER
Gives hundredth turn readings visible when fingers are on adjusting knob. Registers to 999 and repeats. Friction lock secures setting. Available with dial light and for remote operation.



INDEXING METER WITH SWITCH
Developed for use with wire and tape recorders. Switches are actuated automatically at fixed "index numbers" for which the unit is built. Many variations available for a wide range of application.

LOW BACK-LASH COUNTER ASSEMBLY
Rugged, add-subtract revolution counter assemblies widely used as indexing registers for potentiometers, variable capacitors and other digital readout requirements. Wide choice of optional features.

7-DIGIT REVOLUTION COUNTER
Non-reset. Adds or subtracts 10 counts per shaft revolution. Top-coming or top-going shaft rotation. Totally enclosed in die cast housing. Available sealed; also with adaptor for flexible shaft drive.

PIC G C

Manufacturers of Counters, Switches, Relays, Actuators and Automatic Valves

AUTOMATION CONTROLS DIVISION

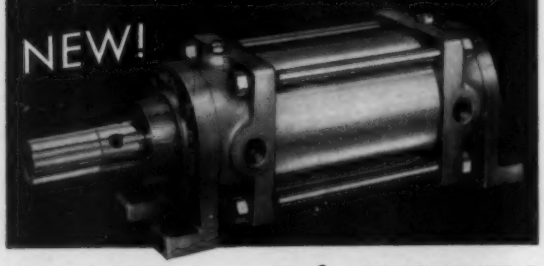
GENERAL CONTROLS CO.

8072 McCormick Boulevard, Skokie, Illinois

Representatives and Distributors in Principal Cities of United States and Canada

FREE CUSHIONS*

NEW!



*ALL MEAD Dura-Life CYLINDERS

New line of Mead air cylinders, 16 sizes, mounts. Larger-than-ever ram bearing holds strict alignment, eases friction. Quick-detachable bearing cartridge to replace ram seals in minutes. Adjustable, convertible cushions, non-cushions or semi-cushions at either or both ends. Universal cylinders with interchangeable mounts (200 PSI). *Millions* of cycles prove they will take it. Get complete data from . . .

with **DOUBLE CUSHIONS** at **NO EXTRA COST**

MEAD SPECIALTIES COMPANY

4114 N. Knox Ave.
Dept. 1480
Chicago 41, Illinois

CIRCLE 210 ON READER SERVICE CARD

When it's a Question of

"O" RINGS in any material or special compound for every service condition required.

PACKINGS to your specifications in leather, synthetics, asbestos, teflon, etc.

Also gaskets and washers in over 200 materials . . .

Look for the Answer at Auburn . . .

Send us your specifications or blueprints. You'll receive prompt quotations and recommendations without obligation

THE **AUBURN** MANUFACTURING CO.
306 Stock St., Middletown, Conn.

New York, N. Y.; Rochester, N. Y.; Detroit, Mich.; Chicago, Ill.; Minneapolis, Minn.; Pittsburgh, Pa.; Cincinnati, Ohio; Ridgewood, N. J.; Atlanta, Ga.; Memphis, Tenn.; St. Louis, Mo.; Washington, D. C.

CIRCLE 211 ON READER SERVICE CARD

VIKING
POSITIVE DISPLACEMENT PUMPS
HELP YOU TO:

CHOOSE from over 800 catalog models or thousands of special models.

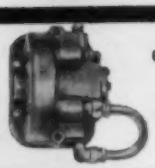
SAVE space on custom built, stripped models or compact standard construction.

SPECIFY exact size and capacity needed—also materials of construction.

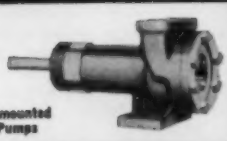
OPERATE pumps in either direction, including reversible operation.

DEVELOP pressures up to 500 lbs. (hydraulic oils), 200 lbs. (heavy duty), 100 lbs. (general purpose).

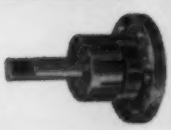
Motor Mounted Pumps



Custom-built Pumps



Unmounted Pumps



Stripped Pumps

For complete information, ask for catalogs BX, CX and SP-809X

VIKING PUMP COMPANY

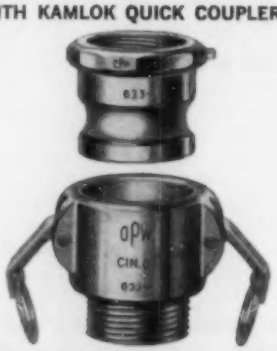
Cedar Falls, Iowa, U.S.A. In Canada, It's "ROTO-KING" Pumps

See Our Catalog in Sweet's Product Design File

CIRCLE 94 ON READER SERVICE CARD

IT'S EASY

WITH KAMLOK QUICK COUPLERS



You save production time . . . when you replace time-wasting hose and pipe connections with Kamlok Quick Couplers. No tools needed. Your operator can do the job himself. Just fit together and pull the two cam arms down. Use them wherever your hose or pipe connections are periodically uncoupled (once a week or oftener). We probably have one to fit your needs. Why not send for more information? Inquiries are invited.

Fastest—safest—surest couplings known.

4

OPW-JORDAN
6013 Wiehe Road
Cincinnati 13, Ohio

CIRCLE 212 ON READER SERVICE CARD

DESIGN LITERATURE

Engineering Thermodynamics

NEWMAN A HALL, WARREN IBELE. Prentice-Hall Inc, Englewood Cliffs, NJ. 6 x 9, 640 pp. $10.50.

This college text has a unique approach with a completely new pattern of emphasis, and includes results of years of research by the authors into the behavior of fluids. It has a rather independent point of view, especially wherein the thermodynamics of solids and magnetic fields becomes as complete as the thermodynamics of fluid substances. At the beginning of each chapter is a lucid explanation of the background for each topic.

Comprehensiveness is indicated by titles of some unusual chapters: Fluids (gases & Liquids); Solids, Processes Phase Equilibrium; Processes with Varying Composition; Chemical Reactions; Fluid Flow. All of the usual chapters (first and second laws, etc.) are also included.

Polystyrene

WILLIAM C TEACH, GEORGE C KIESSLING. Reinhold Publishing Corp, 430 Park Ave, New York 22. 5¼ x 7½, 176 pp. $5.

This book is an introduction to the properties, manufacture and use of polystyrene. The approach is semi-technical, and the text is aimed at engineers, designers and students. Physical and chemical properties are explained, including a simplified discussion of polymer chemistry. Stress is on uses of polystyrene, but well known and new fabrication processes are also discussed.

Endurance Tests of Rolling-contact Bearings

WALP, REMORENKO, PORTER. (WADC Technical Report 58-392) AD-212904, Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 11, 76 pp. $2.25.

(Full title: "Endurance Tests of Rolling-contact Bearings of Conventional and High-temperature Steels Under Conditions Simulating Aircraft Gas-turbine Applications.")

Endurance tests of rolling-contact bearings of conventional and high-temperature steels were conducted at two temperature levels and at normal and high speeds. Test results indicate that the fatigue life of the high-temperature steels is materially increased by vacuum melting. High-speed ball-bearings, alike in all respects except for ball-diameter variations, were tested at high speed to study dimensional effect on endurance life. Results of the endurance tests indicate no correlation of individual bearing life with observed dimensional variations for the same bearings.

To provide a means of determining the fatigue properties of materials without using complete bearings, simple specimen-testing machines were designed and operated. Results of these tests, based on median test lives, seem to indicate some correlation with the lives of deep-groove bearings made from the same materials.

The Theory of Space, Time and Gravitation

V FOCK. Pergamon Press, 122 E 55th St, New York 22. 6 x 9, 411 pp. $15.

Covers both special relativity and what is usually called general relativity. Its earlier chapters present standard theory at a level at which it can serve as a textbook for final-year students in mathematical physics as well as research students. The remaining parts of the book are on postgraduate level, but nevertheless the subject matter is presented with the detail of a textbook rather than a special treatise.

Other Books of Interest

Some Elevated-temperature Properties of Precipitation-hardened Iron–Aluminum Alloys

PB 161543. W J Buehler, C G Dalrymple. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 10½, 16 pp. 50¢.

Structural Damage in Thermally Cycled Rene 41 and Astroloy Sheet Materials

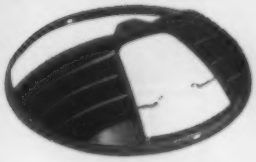
PB 151083. DMIC Report 126. Defense Metals Information Center, Battelle Memorial Institute, Columbus 1, Ohio. Available from Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 24 pp. 75¢.

The Surface Chemistry of Metals and Semiconductors—a Symposium

Edited by H C Gatos. John Wiley & Sons Inc, 440 Park Ave South, New York 16. 6 x 9¼, 521 pp. $12.50.

continued on page 96

RELIABILITY!
VERSATILITY!



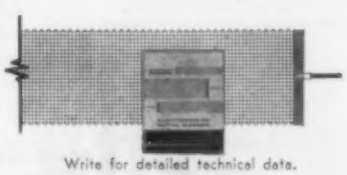
. . . APPLIED DIRECTLY TO THE PART

. . . OR TO DETACHABLE COMPONENTS

. . . OR FORMED AS THE PART ITSELF

ELECTROMESH HEATING ELEMENTS

The ultimate in **reliability** is obtained with this new wire mesh heating element . . . Its current is carried by 36 parallel wires (per inch width of conductor) . . . also 30 wires are interwoven perpendicular to the flow of current. In the event of broken wires or partial open circuits, these cross wires act as **buss bars** . . . **redistributing** the current, restoring the element to full power.

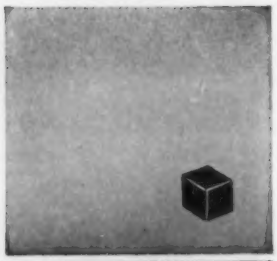


Write for detailed technical data.

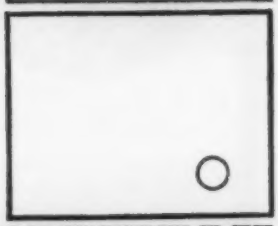
Electrofilm INC.

P.O. BOX 106, NORTH HOLLYWOOD, CALIFORNIA

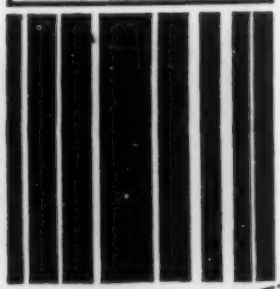
CIRCLE 95 ON READER SERVICE CARD



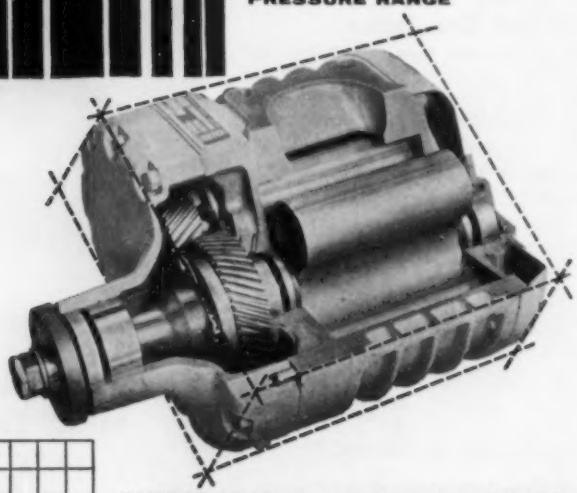
SMALLEST CUBE DIMENSIONS

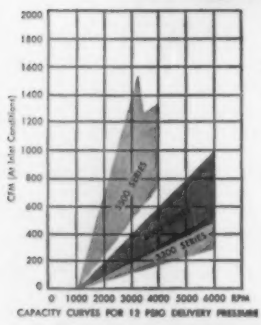


LIGHTEST WEIGHT



WIDEST PRESSURE RANGE





WITH M-D 3-LOBE BLOWERS

If space and weight of the blower is a concern in your design problem, consider this fact. M-D rotary positive blowers because of their unique 3-lobe design require smaller cubic space than any other blowers. A survey shows that a 14 PSI M-D takes 3/4 to less than 1/10 the space of competitive models . . . and in some cases are only 1/10 the weight.

M-D Blowers operate at wider pressure and speed ranges than any other rotary positive blower. Capacities of 11 production models range from 50 to 4000 CFM, pressures to 14 PSIG single, 70 PSIG multi-stage.

For full information write

M-D BLOWERS, INC., RACINE, WISCONSIN

A Subsidiary of Miehle-Goss-Dexter, Inc.

Organo-metallic and Organo-metalloidal High-temperature Lubricants and Related Materials —Part 4

H Gilman, R D Gorich. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 63 pp. $1.75.

The synthesis and preliminary thermal screening for 36 compounds is described.

Development and Evaluation of Structural Beryllium

PB 161507. C J Giemza. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8¼ x 11, 60 pp. $1.75.

Proceedings of the National Electronics Conference, Vol. 15

National Electronics Conference Inc, 228 North LaSalle St, Chicago 1. 6 x 9¼, 1089 pp. $10.

ABSTRACTS FROM THE LITERATURE

Measurement Accuracy

The possibilities of improving the usefulness of a measurement instrument by considering the effect of the measurement accuracy on the estimated mean and variance of the measured quantity are discussed. Maximum likelihood theory is used to extract full information from a set of data with different degrees of accuracy.

"Measurement Accuracy as a Weighting Factor in Statistical Treatment of Data," D. M. Aspinwall and J. F. Rey, Lockheed Aircraft Corp. Instrument Society of America paper 66-NY60, 313 Sixth Ave, Pittsburgh 22.

Power-cable Shielding

Describes a laboratory investigation in which resistance, inductance, and capacitance of cables with variations in shielding were measured at high frequencies, using techniques which, in general, might permit the simulation of surge conditions.

"Characteristics of Power-cable Shielding," by T. N. Mitropoulos, R. J. Fogel and C. J. Tang, Simplex Wire and Cable Co, Cambridge, Mass. Electrical Engineering, Sept '60, 33 W 39th St, New York 18.

Adhesives Limit Strain Gages

A survey is presented on the manner in which adhesives determine and limit strain-gage behavior. It is shown that it is not possible today to predict gage behavior on the basis of knowledge of the gage construction and adhesive properties, although competent research in this area is being carried on. Adhesive properties as

they affect strain-gage behavior are discussed and a number of very practical and direct operating consequences for the strain-gage user are derived from these considerations. These "laws" are summarized in the "Conclusions" section of this study.

"Adhesives, How They Determine and Limit Strain-gage Performance," Peter K. Stein, Arizona State Univ. Instrument Society of America paper 7-NY60, 313 Sixth Ave, Pittsburgh 22.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 101.

WHEELS AND CASTERS—Booklet, 75 pp. Compares company's line of casters to that of five other manufacturers. Lists most caster models and their physical characteristics. Comparisons cover most dimensional specifications, capacity, finish and construction features. Colson Corp, 7 S Dearborn St, Chicago.

Circle 350 on Reader Service Card

MOUNTING TECHNIQUES—Manual 212-G, 72 pp. Compilation of materials and specifications, recommended applications and latest techniques for mounting tubing, wiring and similar hardware. Also describes line of clamps, brackets, shims and line supports. TA Mfg Co, Engineering Dept, 4607 Alger St, Los Angeles 39.

Circle 351 on Reader Service Card

ELECTRONIC CONTROLS—Catalog 60, 24 pp. Describe developments in high-speed, ultrasensitive and impulse-actuated controls, as well as controls actuated by current surge and impact. Includes several pages of application diagrams for photoelectric controls. Autotron Inc, Box 722V, Danville, Ill.

Circle 352 on Reader Service Card

CUSTOM-PRODUCED GLASS—Bulletin 760, 16 pp. Covers engineering and manufacturing service, from application analysis and formula development through mold design and custom production. Describes how special glass products are designed and produced with proper combination of properties to meet specific applications. Kopp Glass Inc, Swissvale, Penna.

Circle 353 on Reader Service Card

FLUID ACCUMULATORS—Catalog, 23 pp. Contains specifications, dimensions and capacity information on accumulators of 1 pt to 23 gal capacities. Also includes construction drawings and pres-

continued on page 99

WANT THE LATEST INFORMATION ON GLOW LAMPS AS INDICATORS AND AS CIRCUIT COMPONENTS?

Send for General Electric's all-new Glow Lamp Guide for Designers. It's free, complete and up-to-date—

Contains all the information you'll need to help you choose the right glow lamp for the job. Gives complete specs on G-E Glow Lamps for circuit component and for indicator use. Packs more data in fewer pages than any other brochure . . . recommends specific lamps for specific circuits . . . covers physical and electrical characteristics. All this and much, much more. Send for your free copy of Bulletin No. 3-0193 today. The right number for you to circle is shown below. General Electric Co., Miniature Lamp Dept. M-031, Nela Park, Cleveland 12, Ohio.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Sensitive H9 J10

PRESSURE and VACUUM CONTROLS

UNITED ELECTRIC's Type H9 and Type J10 controls are highly sensitive precision built pressure and vacuum controls designed for applications where close on-off differentials and constant repeatability are required. Type J10, being uncalibrated, is smaller and less expensive than Type H9 which is calibrated and has a knob & dial adjustment.

Specs:	
Various Ranges	H9-J10 — between 30" Hg. Vac. and 15 P.S.I.
Switch Differentials	H9 — ½ to 1 ±1/10" W.C. depending upon model. J10 — ¾ to 1 ±3/10" W.C. depending upon model.
Switch Ratings	Standardly 3 amps 115/230 A.C.
Switch Types	N.O., N.C., or Double throw, no neutral position.
Electrical Connections	Made to screw terminals on switches through clearance hole in enclosure.
Pressure Connections	One ¼" NPT pressure connection.
Size	H9 — 7" x 3⅜" dia. J10 — 6⅛" x 3⅜" dia.
Approximate Weight	H9 — 3 lbs. J10 — 2¾ lbs.

UNITED ELECTRIC *manufactures a complete line of temperature, pressure, and vacuum controls. For applications requiring custom-built units or modified standard units, call upon a UE application engineer for recommendations. Write for complete specification and pricing data on the Types H9 and J10. Similar data available on all other UE controls.*

United Electric Controls
COMPANY
85 SCHOOL STREET, WATERTOWN, MASS.

98 CIRCLE 98 ON READER SERVICE CARD

WECKESSER

molded
BLACK NYLON
SCREWS
and
NUTS

Acid resistant . . .
Need no insulation . . .
Can't rust . . .
Can't corrode . . .

CUT ASSEMBLY TIME

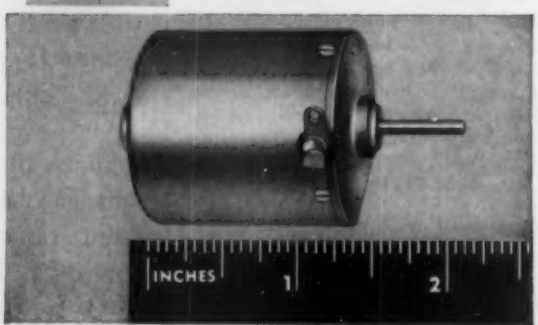
2-56, 4-40, 6-32, 8-32, 10-32 and 1-20 in stock. Actual production samples will give you the whole story. Write on your letterhead.

WECKESSER COMPANY
5705 Northwest Hwy. • Chicago 46, Ill.

CIRCLE 213 ON READER SERVICE CARD

THE MARK OF QUALITY
BARBER COLMAN

can you use this miniature d-c motor in your product?



Inexpensive, yet high in quality, this compact governed d-c motor is available in speeds from 1500 to 5000 rpm. Designed to operate over a voltage range of about 4 to 30 volts d-c, it is ideally suited for many applications such as: drive mechanisms in photographic equipment . . . marine navigation equipment . . . portable dictating machines . . . signal-seeking radios . . . tape players . . . and many types of portable instruments. Is this the answer to *your* design problem, too?

WRITE FOR BULLETIN F-8792 for specifications and performance data.

BARBER-COLMAN COMPANY
Dept. K, 1812 Rock Street, Rockford, Illinois

CIRCLE 214 ON READER SERVICE CARD

sure volume curve on each model. Fluid Power Div, Hale Fire Pump Co, Conshohocken, Penna.

Circle 354 on Reader Service Card

CYLINDER-FORCE CALCULATION—Chart. Includes chart of effective areas and nomogram for force determination (force = effective area × pressure). Shelffer Corp, Cincinnati 15.

Circle 355 on Reader Service Card

PLASTIC VALVES AND FITTINGS—Bulletin, 16 pp. Describes various products available in PVC. Includes application table that rates PVC's effectiveness on over 300 fluids; section on specifications and dimensions of all PVC valves and fittings. Walworth Co, 750 Third Ave, New York 17.

Circle 356 on Reader Service Card

SPRING MATERIALS—Information kit. Contains data sheets, 8-page bulletin explaining basic advantages of several different spring materials. Riverside-Alloy Metal Div, H K Porter Co Inc, Riverside, NJ.

Circle 357 on Reader Service Card

MECHANICAL - POWER - TRANSMISSION EQUIPMENT — Catalog 23103, 8 pp. Describes and illustrates line of mechanical-power-transmission equipment, including drives, pulleys, couplings, motor bases, pillow blocks and bushings. T B Wood's Sons Co, Chambersburg, Penna.

Circle 358 on Reader Service Card

TRANSISTOR-EQUIPPED TEMPERATURE CONTROLS—Bulletin MC-190, 8 pp. Specifications and features of four temperature controllers offering transistor circuits and thermistor sensing elements. With sketches of various application arrangements. Fenwal Inc, Pleasant St, Ashland, Mass.

Circle 359 on Reader Service Card

RECEIVER GAGES—Catalog 520, 8 pp. Gives specifications, information on materials, construction, sizes and ranges of dial-indicating receiver gages. US Gauge, Div of American Machine and Metals Inc, Sellersville, Penna.

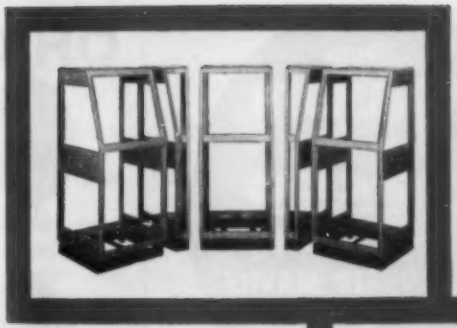
Circle 360 on Reader Service Card

PRINTED CIRCUIT BOARD—Catalog sheet, 2 pp. Describes stock, paper-base epoxy, printed circuit board. Includes applications, stock sizes and prices. Elgin Laboratories Inc, Waterford, Penna.

Circle 361 on Reader Service Card

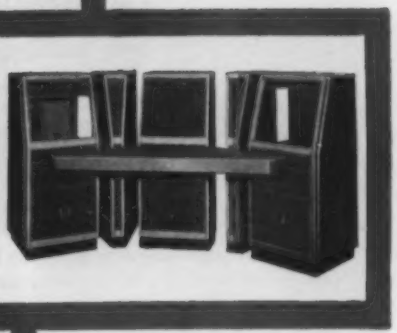
MINIATURE TRANSFORMERS—Catalog 600, 24 pp. Lists specifications and prices of off-the-shelf miniature transform-

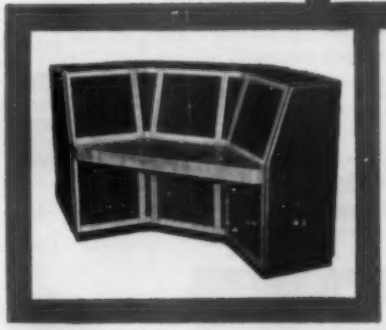
continued on page 101



CONTROL CENTER ASSEMBLY

FEATURES ERECTOR SET SIMPLICITY WITH . . .





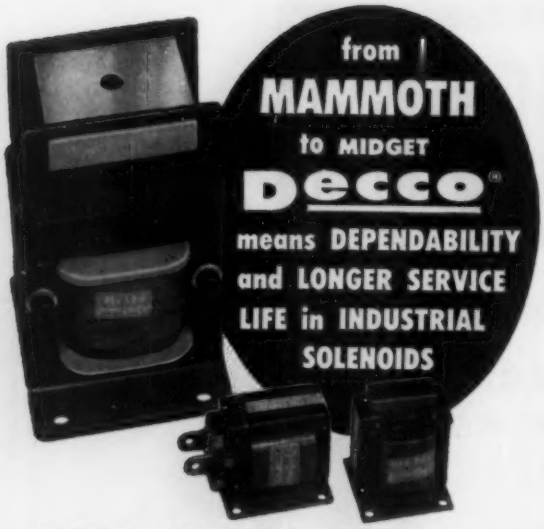
EMCOR® STANDARD CABINETS

The ultimate in packaging flexibility is available to help reduce costly design time and custom housing modification. The photographs above graphically illustrate the ERECTOR SET SIMPLICITY in assembly attained through the use of EMCOR Standard Cabinets. Speed of assembly is only one advantage attained with EMCOR Enclosures. Choose from over 600 basic frames plus thousands of components and associated equipment of the EMCOR MODULAR ENCLOSURE SYSTEM. Discover for yourself, the compatibility which can be attained by using any combination of frames and components, the lasting and aesthetic beauty of cabinet design and appearance plus the proven structural capabilities of the EMCOR Fine Line of Quality. Contact your local EMCOR Sales Engineering Representative or write for full details today.

Condensed Version of Catalog 106 Available Upon Request.

Originators of the Modular Enclosure System

Ingersoll PRODUCTS DIVISION
BORG-WARNER CORPORATION
630 Congdon Avenue Dept. 1240 Elgin, Illinois



from
MAMMOTH
to MIDGET
Decco®
means DEPENDABILITY and LONGER SERVICE LIFE in INDUSTRIAL SOLENOIDS

DECCO solenoids' unique engineering features and top quality materials have greatly extended their service life.
There is a DECCO solenoid to meet your requirements. Oil immersed, push or pull, shock mounted, A.C. or D.C., mammoth or miniature, they have to be good to be DECCO. Write for catalog.

DETROIT COIL COMPANY
2435 Hilton Road • Ferndale 20, Mich.

CIRCLE 215 ON READER SERVICE CARD

OHIO WELD NUTS

RH NUT
Thread Size 6-32 to 3/8-16

WF NUT
Thread Size 6-32 to 3/8-16

SF NUT
Thread Size 5/16-18 to 1/2-13

WW NUT
Thread Size 6-32 to 3/8-16

OHIO flanged weld nuts provide extra-long thread engagement and are ideal for assemblies requiring strong primary fasteners. They can also serve as spacers or bearing surfaces where required.

Samples and information furnished upon request.

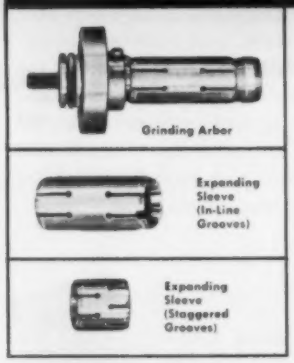
The Primary Fastener in Fastener Assemblies

THE OHIO NUT AND BOLT CO.
41 FIRST STREET BEREA, OHIO

CIRCLE 216 ON READER SERVICE CARD

NEW La Salle EXPANDING ARBORS*

accurately position any type of part or tool for machining, grinding and inspection operations



ADVANTAGES

Vise Like Grip
Better Balance
Squareness of Faces
Better Finish
Improved Design
Closer Concentricities
No Wobble
Any Size

- Ends expand independently
- Expansion can be different at each end
- No loose or movable parts—centrifugal force will not throw arbor out of balance

WRITE FOR CATALOG SHEET NO. 120 *Patent Pending

La Salle machine tool, inc.
SPECIAL MACHINE TOOLS
21535 Hoover Road • Warren, Michigan

DRUM CAM

Cams and Camshafts

precision milled or ground

by the world's leading CAM manufacturer

LANDING GEAR CAM

PUMP CAM

Eonic is regularly supplying Landing Gear, Drum, Pump, Face, Cylindrical two and three dimensional Cams to manufacturers throughout the world.

Design Analysis and Engineering Services Available.

EONIC *Inc.* Engineers of Precision

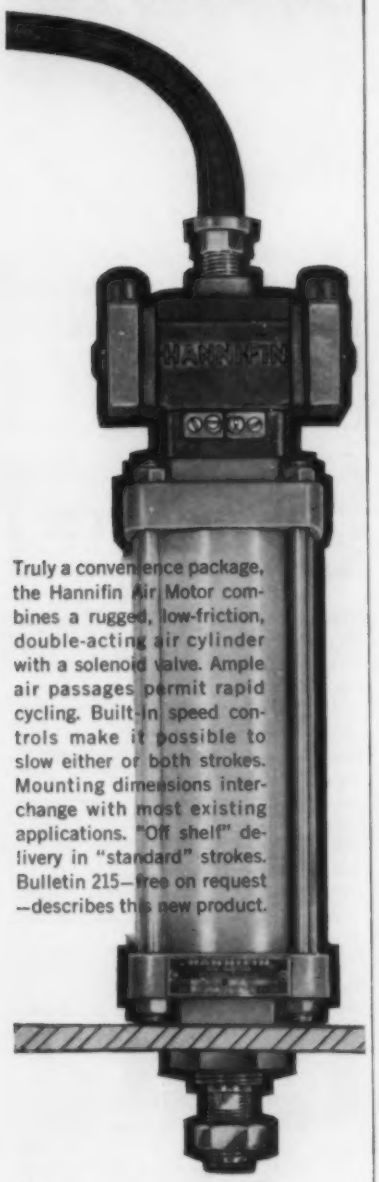
Write for catalog and additional information

459-B E. Hollywood • Detroit 3, Michigan

CIRCLE 100 ON READER SERVICE CARD

CIRCLE 217 ON READER SERVICE CARD

HANNIFIN
has a faster, more rugged
AIR MOTOR



Truly a convenience package, the Hannifin Air Motor combines a rugged, low-friction, double-acting air cylinder with a solenoid valve. Ample air passages permit rapid cycling. Built-in speed controls make it possible to slow either or both strokes. Mounting dimensions interchange with most existing applications. "Off shelf" delivery in "standard" strokes. Bulletin 215—free on request—describes this new product.

PARKER HANNIFIN CORPORATION
PNEUMATIC AND HYDRAULIC SYSTEM COMPONENTS

HANNIFIN COMPANY
A DIVISION
625 South Wolf Road
Des Plaines, Illinois

3155-PH

ers. With dimensional diagrams. Microtran Co Inc, 145 E Mineola Ave, Valley Stream, NY.
Circle 362 on Reader Service Card

ALLOY IRON PROPERTIES—Bulletin 158, 8 pp. Charts mechanical properties, physical properties and chemical composition of various centrifugally cast irons. Also describes and illustrates component parts and assemblies produced by centrifugal method. Centrifugally Cast Products Div, Shenango Furnace Co, Dover, Ohio.
Circle 363 on Reader Service Card

ROCKER-TYPE FOOTSWITCHES—Bulletin, 2 pp. Specifications and descriptions of maintained contact and single and two-stage momentary footswitches. Linemaster Switch Corp, 432 Woodstock Terrace, Woodstock, Conn.
Circle 364 on Reader Service Card

DOOR INTERLOCK SWITCHES—Data sheet 178, 2 pp. Includes photos, mounting dimension drawings, mechanical characteristics, electrical ratings and prices of three series of door interlock switches with thermoplastic actuating rods. Micro Switch, Freeport, Ill.
Circle 365 on Reader Service Card

MINIATURE PRECISION DIFFERENTIALS—Data sheets 2001 and 3001, 2 pp each. Cover design features, specifications and dimensions of solid and hollow shaft differentials, respectively. Empire Flight Components Inc, Merrick Rd, Bellmore, NY.
Circle 366 on Reader Service Card

BRAIDING PRODUCTS—Catalog, 4 pp. Presents characteristics of flat, oval commercial and tubular braid. Includes application information and glossary of shielding and braiding terms. Alpha Wire Corp, 200 Varick St, New York 14.
Circle 367 on Reader Service Card

MECHANICAL SHAFT SEALS—Brochure SS-607, 4 pp. Specifications, dimensions and construction information for mechanical shaft seals for rotating shafts. Installation diagrams show various seal models in use. Syntron Co, 240 Lexington Ave, Homer City, Penna.
Circle 368 on Reader Service Card

LETTERHEAD REQUESTS ONLY

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

ALL-METAL FLEXIBLE HOSE—Catalog ID-100D, 20 pp. Descriptions, specifications and application information, together with coupling recommendations

continued on page 102

How to improve equipment designs

Above: O. C. White Model G2MC Incandescent Fixture with Koolguard hot lamp protector. Ultra-flex arms permit moving light to any position.
Below: Stocker & Yale Sealed Fluorescent Unit #SP-24. Provides complete protection against dust, oil, etc. Easily wiped clean.

. . . Add a supplementary light and you might well have the answer

Proper illumination of work areas is a necessity if operators are to get the most out of equipment. Stocker & Yale and O. C. White supplementary lights give the illumination they need . . . clear, concentrated, high level, glare-free. And, too, these lights add a profitable selling feature at very little extra cost.

There's a Stocker & Yale or O. C. White Light just right for every requirement: standard or special • fluorescent or incandescent • choice of arms, bases, switches, ballasts, reflectors • available with optically ground magnifiers • sealed units for protection against dust, oil, etc. • arms easily adjustable • advanced electrical and mechanical designs • high quality construction and manufacture.

Engineering Assistance — on special applications, or where you have a problem, let our engineers provide the answers.

O. C. White Lights distributed nationally by O. C. White Sales Co., Marblehead, Mass.

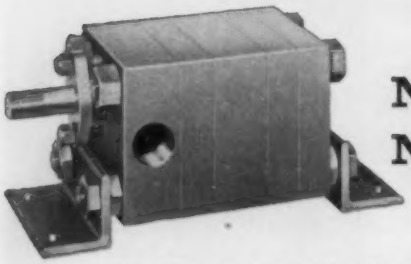
STOCKER & YALE

Lite-Mite Lights — O. C. White Lights

Want Details? ☐ Catalog of standard lights ☐ Special requirement outlined in letter

Just clip to your letterhead, sign and mail to: STOCKER & YALE, INC., 46 Green St., Marblehead, Mass.

for pumps as individual as a fingerprint!



SPECIFY NORTHERN NITRALLOY PUMPS

Northern designs and builds quality into every pump. For each application, materials are selected with infinite care—gears with ground tooth form for perfect contact, correct clearances. Meticulous inspection at every stage in the manufacturing process assures efficient, economical, lasting service for even the most difficult pumping tasks under rugged conditions, indoors and out, year after year.

Northern Nitralloy Pumps are available in capacities from ¼ to 146 GPM at pressures up to 2000 PSI. Within this range there is a pump as individual as a fingerprint — as "special". as you want it.

Write today for free catalog and engineering data.

Northern Ordnance Incorporated
Subsidiary of NORTHERN PUMP COMPANY
Minneapolis 21, Minnesota

CIRCLE 219 ON READER SERVICE CARD

Strataflo
ALL-POSITION
CHECK VALVE

Sensitive, Rugged

METAL POPPET

For steam, hot or cold water, oil, gas, and compounds.

Designed for rugged service. Also available with Buna rubber poppets for use with air or cold water. Sensitive in operation. Work in any position. Made in seven sizes, 200 lbs. pressure. We will design special Check Valves; tell us your needs. Write for Bulletin 201 and prices.

STRATAFLO PRODUCTS, INC.
FORT WAYNE, INDIANA

EMPLOYMENT OPPORTUNITIES

DISPLAYED RATE

The advertising rate is $37.00 per inch for all advertising appearing on other than contract basis. Frequency rates quoted on request.

UNDISPLAYED RATE

$2.10 per line, minimum 2 lines. Position Wanted ads in this style ½ the above rate. To figure advanced payment count 5 average words to a line.

ADDRESS BOX NO. REPLIES TO: Box No. Classified Adv. Div. of this publication. Send to office nearest you.
NEW YORK 36: P. O. Box 12
CHICAGO 11: 520 N. Michigan Ave.
SAN FRANCISCO 4: 68 Post St.

POSITIONS VACANT

Chief Designer: One of the largest national manufacturers of quality lighting fixtures for commercial, industrial and institutional application. Must be conversant with all materials and technology pertaining to the design, development and manufacture of fluorescent lighting equipment. Should have creative ability. Locate in Southern California. Salary excellent, commensurate with experience. Send resume in confidence to P-5329, Product Engineering.

for all-metal flexible hose. Universal Metal Hose Co, 2133 S Kedzie Ave, Chicago 23.

SOLENOIDS, COILS, TRANSFORMERS—Catalog, 20 pp. Performance charts, features and specifications of various solenoids, coils, transformers and electrical components. Illustrated with dimensional drawings and photos. Anderson Controls Inc, 9959 Pacific Ave, Franklin Park, Ill.

FOR MORE CATALOGS AND BULLETINS . . .

. . . 1600 of 'em—see your copy of Product Engineering's Mid-Sep 1960 Design Digest. There you will find helpful design literature, classified under 10 different headings, from important manufacturers and suppliers of components, materials, power and control systems, manufacturing processes.

REPRINTS

Reprints currently available without charge are listed on the Reader Service Card bound in this issue. Single copy free; quantity prices on request.

The following special reports are available as long as the supply lasts, from Reader Service Dept., Product Engineering, 330 W 42nd St, New York 36. Please enclose remittance with order; we pay postage.

R48—Reinforced Plastic Parts
Combined reprints of 11 articles giving design data on the seven processes for commercial parts, 64 pp. $2

R69—Human Engineering
Series of 14 articles with design data on man-machine problems, plus bibliography, 44 pp. $1.50

R66—The European Engineer Talks
The challenge to American proficiency in design for production disclosed by interviews with technical directors in six countries, 24 pp. $1

R16—Plate Cam Design
Series of 7 articles with complete design data; curve blending and profile synthesis to reduce inertia, 48 pp. $1

R65—Reading, Writing, Reporting
Combined reprint of: 5 steps to faster reading; 8 steps to better writing; 7 steps to better reporting, 24 pp. $1

3 WAYS BETTER

ALBION'S NEW SERIES 16 CASTERS

Another completely new . . . completely practical Albion industrial caster series developed to serve a broader variety of applications. Conservatively rated as medium duty casters, yet constructed for longer, better . . . heavy duty, maintenance-free service. They're three ways better, and here's why:

1. MORE CAPACITY

The new Series 16 Casters offer Albion's finest, most dependable construction advantages such as "cold-formed" steel yoke base and top plate with heat-treated raceways for smoother, lasting maneuverability under greater capacity loadings.

2. MORE WEARABILITY

Albion's Series 16 Casters are available in nine different high capacity or floor protective wheel types in diameters of 3¼" to 8" with a capacity range of 140 to 900 lbs. per wheel. Sound engineering, quality materials and craftsmanship plus Albion's many outstanding construction features are combined to afford a caster that will last and last and last.

3. LESS COST

Although built to Albion's exacting quality standards, the Series 16 cost you far less than most ordinary casters of the same size or capacity ratings. And . . . they are available—all models—right now!

RIGID CASTERS
Albion's Series 16 Casters are available as matching rigid models in 9 wheel types—3¼" to 8" wheel diameters.

Remember . . . if you want longer, better service plus caster versatility at a savings you can count—be sure to get all the facts and figures from Albion.

Write—wire or phone today for your copy of the new illustrated specification sheets on Albion Series 16 Casters.

ALBION INDUSTRIES, INC.
Albion Michigan

R46—Manual of Reliability
How to design for reliability, human factors, statistical tools; implementing the program, 32 pp. 50¢

R41—Design by Digital Computers
How to choose and operate desk-size problem solvers. 50¢

R22—Engineering Organization
Study of 50 companies shows changes in large and small companies, 24 pp. 25¢

R21—Engineer's Bookshelf
Annotated bibliography of technical books for the design engineer, 24 pp. 25¢

R74—Right-angle Gears
Guide to 16 available types 25¢

R73—Digital Readouts
How they work; how to choose. 25¢

R72—Spring Tolerances
When standard tolerances won't do. 25¢

R71—How to Design Nomographs
Simple step-by-step guide. 25¢

R70—Gasket Materials
Four-step selection procedure. 25¢

R68—Encapsulating Systems
Comparison of basic systems. 25¢

R67—Heat Protectors for Motors
Response and accuracy of all types. 25¢

R64—Bonded Solid Lubricants
Data on new high heat types. 25¢

R62—High-speed Photography
How it can solve design problems. 25¢

R61—Angular Errors in Gearing
Equations predict seven effects. 25¢

R60—Journal Bearing Design
New Equations and design charts. 25¢

R58—How to Avoid Hose Failure
For metal hose; all known causes. 25¢

R56—Buckling of Coil Springs
How to predict. 25¢

R54—Solid Aluminum Bearings
Materials and design guide. 25¢

R53—Significance of WK²
Selecting motors for high inertia loads. 25¢

R51—Solder Fluxes
Selection guide covering all types. 25¢

R49—Positive-displacement Pumps
Graphical method and selection chart. 25¢

R47—Fastening Gears to Shafts
Comparison table for 15 methods. 25¢

R38—Design of Circular-arc Cams
Mathematics replaces graphics. 25¢

Example . . .

. . . of B & P capability to make lightweight metal assemblies for electronic equipment

Designing and manufacturing products and assemblies of light metals is a highly specialized field. Techniques unknown to production in other metals must be understood and new ones must be developed for unusual requirements.

Because it has concentrated on light metal manufacturing for many years, Brooks and Perkins today has experience and capability unmatched by any other organization.

The Nike-Hercules system magnesium cabinet shown above is just one example of B & P skill in maintaining close tolerances and optimum precision. Other products and assemblies designed and produced by B & P include . . .

• cooler plates • radar reflectors • communication equipment covers • radar reflector bases • equipment housings • tripods • radar plotting equipment • shelters • transit cases • gun fire control housings and turrets

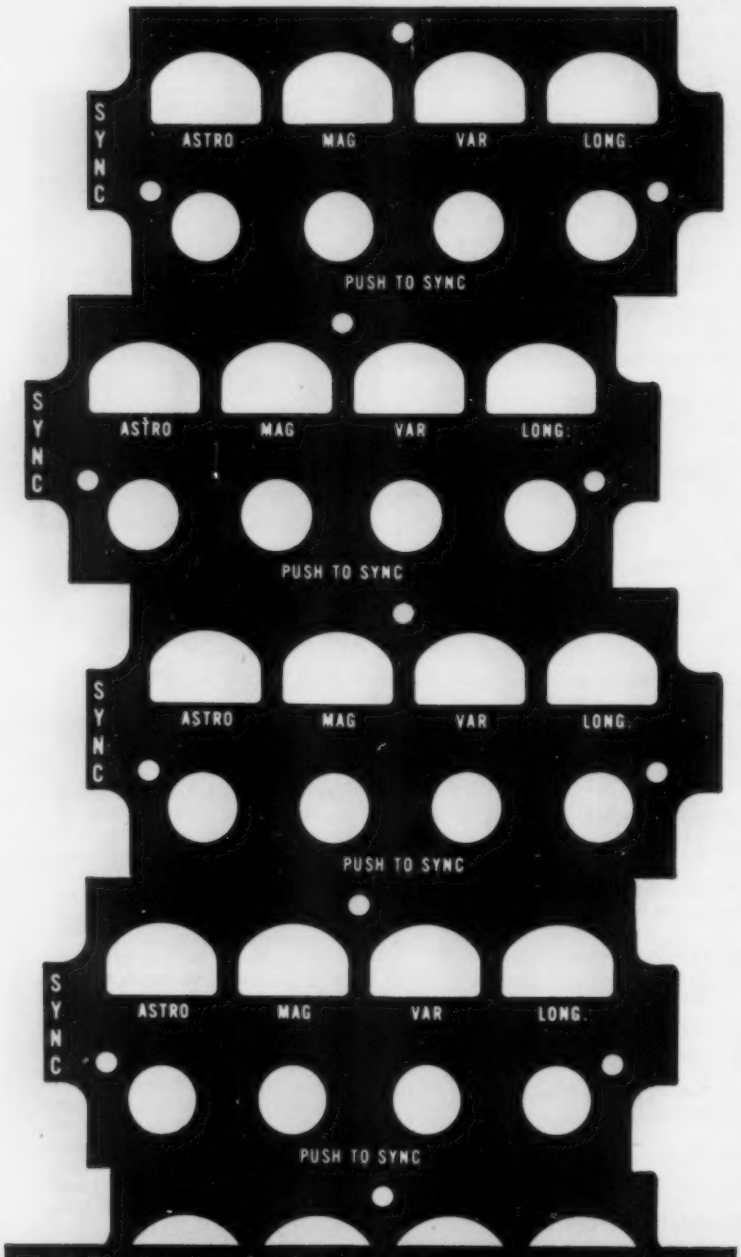
When you need lightweight products or assemblies for electronic equipment, take advantage of B & P's experience and capability.

BROOKS & PERKINS, INC.
1956 W. Fort St., Detroit 16, Mich.
Offices in Washington and New York

61-7-2

CIRCLE 220 ON READER SERVICE CARD

CIRCLE 103 ON READER SERVICE CARD



the shape of things to come

...embedded-circuit instrument panels from United States Radium Corporation—one of four new designs incorporating potted circuits for reliability in a variety of industrial and military applications. / These new Lackon panels feature solder-connected wire circuits with "built-in" protection against physical and environmental effects. All wiring is fitted into specially-grooved slots which are then filled, and the panel back finished to provide a smooth, virtually trouble-free surface. / Investigate these longer-lived panels for your critical design needs.

RADIUM

Write for additional details.

united states radium corporation

MORRISTOWN, N. J. | Offices: Chicago, Illinois and North Hollywood, Calif. Subsidiaries: Radelin Ltd., Port Credit, Ont., Canada and U.S. Radium Corp.-(Europe), Geneva, Switzerland

Index of

PRODUCTS ADVERTISED

In This Issue

After reading the advertisements classified below . . . MORE DETAILED INFORMATION about these products can be obtained by using the READER SERVICE CARD.

A

Adhesives 22-23, 84
Air Motors (see Motors, Air)
Aluminum Coated Sheet & Strip (see Steel, Coated)
Assemblies
  Structural 82, 103

B

Bearing Materials 90
Bearings
  Ball ..... 4th Cover, 36, 38
  Needle 36, 38
  Roller ..... 4th Cover, 36, 38
Blowers 96
Brazing
  Alloys 34

C

Cabinets 99
Cams 100
Carbide Alloys 32
Carbon 18-19
Casters 86, 103
Castings 33
Chains
  Roller 31
Clamps, Fixture 100
Clips 52
Clutches
  Mechanical 28
Connectors
  Electrical 39
Control Panels & Switchboards 104
Controls
  Electrical 98
Conveyor Belts 22-23, 51
Counters 93
Couplers 94
Couplings
  Mechanical 11, 29
Cylinders
  Pneumatic 86, 94

D

Diaphragms 88
Differentials 88
Drafting
  Machines 5, 13
  Supplies 5, 83, 86
Drives
  Right-Angle 44

E

Enclosures 99
Engineering Services (see also Production Services) 103

F

Fabrics, Coated 88
Fastening Methods 7, 52, 82, 92
Fibre 76
Flexible Couplings 11, 82
Floats 106
Flux 34
Forgings 33
Friction Materials 22-23

G

Gaskets 94
Gear Motors (see also Motor Reducers) 49
Gears 84, 88, 105
Graphite 18-19

H

Hard Surfacing 40-41
Heating Units 87, 95

I

Insulation 76

Index of

PRODUCTS ADVERTISED

In This Issue

J

Joints
Universal 82

L

Lamps 101
Lamps, Indicator 97
Laminated Plastics (see Plastics, Laminated)

M

Moldings
Plastics (see Plastic Parts)
Powdered Metal (see Powdered Metal Parts)
Rubber (see Rubber Parts)
Motor Reducers (see also Gear Motors 49
Motors, A-C
Fractional 10, 46-47, 50, 91
Integral 46-47, 50, 91
Motors, Air 101
Motors, D-C
Fractional 10, 46-47, 50, 91
Integral 46-47, 50, 91
Sub-Fractional 98

N

Nickel Alloys 2
Nuts 7, 98

P

Packings 22-23, 94, 108
Pencils 14
Plastic Parts 22-23
Plastics 35, 45, 54
Plastics Laminated 76
Powdered Metal Parts 22-23
Power Packs
Electrical & Electronic 38
Production Services (see also Engineering Services) 103
Pumps
Liquid 89, 94, 102

R

Relays .....3rd Cover
Reproduction Equipment 5, 13, 83
Reproduction Supplies 5
Resins 54
Revolving Joints (see Joints, Swing & Swivel)
Rings 33
Rubber 30
Rubber Parts 22-23, 30, 107

S

Screws 98
Seals .....2nd Cover, 22-23, 42, 94, 108
Sheaves 88
Solenoids 100
Speed Increasers & Reducers 82, 88
Steel
Coated 37
Switches 85

T

Thermostats 98
Timers 26-27
Tools 100
Transmissions 88
Tube Fabricating 48
Tubes 48
Tubing
Seamless 43, 48
Tungsten Carbide 32

V

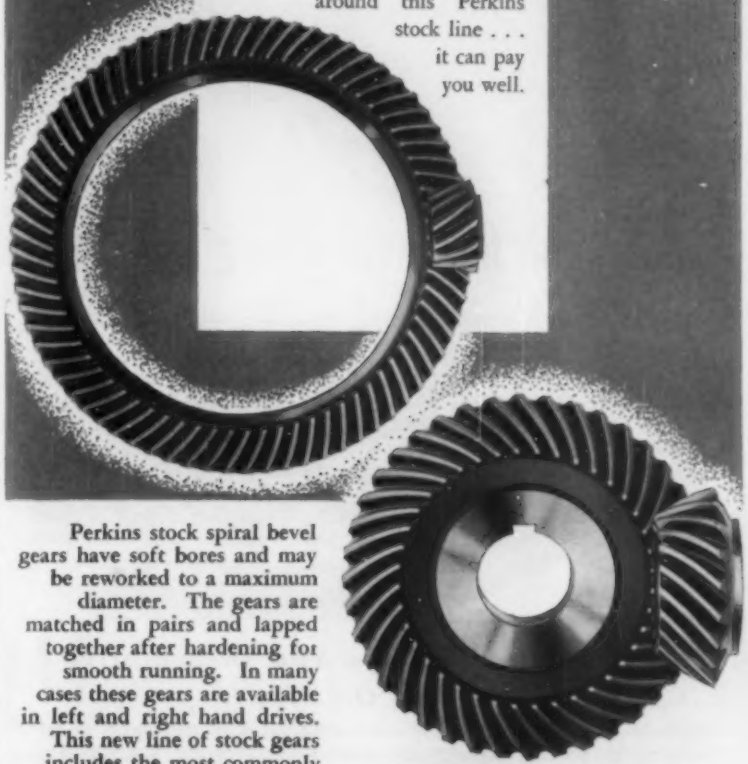
Valves
Air 86
Hydraulic 78, 89, 102

W

Washers 94
Welding
Nuts 100
Wire Cloth 51

NOW... STOCK SPIRAL BEVEL GEARS TO CUT COSTS

Now for the first time Perkins offers a complete line of stock spiral bevel gears with precision quality to help you get maximum savings in tooling expense and gear cost. When you're planning for spiral bevel gears, design your requirements around this Perkins stock line . . . it can pay you well.



Perkins stock spiral bevel gears have soft bores and may be reworked to a maximum diameter. The gears are matched in pairs and lapped together after hardening for smooth running. In many cases these gears are available in left and right hand drives. This new line of stock gears includes the most commonly used ratios and sizes proportioned according to the Gleason Spiral Bevel Gear System.

AVAILABLE ON REQUEST:

This new folder includes all standard specifications of Perkins complete line of stock spiral bevel gears. Write for folder No. 12.

PERKINS
MACHINE AND GEAR CO.
WEST SPRINGFIELD, MASS., U.S.A.

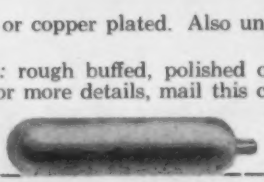
When it comes to floats...

Nicholson has everything you need

High tensile strength floats . . . spherical, elliptical, cylindrical . . . for buoyancy mediums, fluid chambers, pressure vessels . . . and for every mechanism or process requiring floats. Working pressures up to 2500 lbs. Float halves die-formed . . . *not* spun, laminated or electro-deposited. Walls are thus uniformly thick. Seams all butt-welded.

Steel floats: chromium, cadmium or copper plated. Also unplated, with sandblast or pickled finish.

Stainless Steel and Monel floats: rough buffed, polished or with smooth, highly finished welds. For more details, mail this coupon.



This Coupon Brings You Informative Bulletin On Floats

Bulletin 753 contains facts on steel, stainless steel and monel floats, information on float connections, tables showing weight, buoyancy and collapsing pressure for spherical floats for all gauges . . . also volume and buoyancy data. Fill in and mail this coupon for your copy.

Name_____

Title_____

Company_____

Street_____

City_____ Zone_____ State_____

W. H. NICHOLSON and COMPANY
12 Oregon St., Wilkes-Barre, Pa.

NICHOLSON
of Wilkes-Barre

INDEX TO ADVERTISERS

This index is published as a convenience to the readers. Every care is taken to make it accurate but PRODUCT ENGINEERING assumes no responsibilities for errors or omissions

AMP, Inc. 39
Airborne Accessories Corp. 44
Albion Industries, Inc. 103
AllenAir Corp. 86
American Cast Iron Pipe Co. 48
American Cyanamid Co., Plastics & Resins Div. 54
Auburn Mfg. Co. 94
Automatic Switch Co. .....3rd Cover

Baldwin-Lima-Hamilton Corp., Standard Steel Works Div. 33
Barber-Colman Co. 98
Brooks & Perkins, Inc 103
Bruning Co., Inc., Charles 13

Cambridge Wire Cloth Co. 51
Chain Belt Co. 31
Chicago Rawhide Mfg. Co. .....2nd Cover
Continental-Diamond Fibre Co., Subs., Budd Co. 76
Cutler-Hammer, Inc. 26-27

Denison Mfg. Co., R. B. 85
Detroit Coil Co. 100
Dynamic Gear Co., Inc. 88

Eastman Chemical Products, Inc., Chemicals Div. 84
Elastic Stop Nut Corp. of America 7
Electrofilm, Inc. 95
Emcor Ingersoll Products Div., Borg-Warner Corp. 99
Eonic, Inc. 100

Faber-Castell Pencil Co., Inc., A. W. . 14
Fairfield Mfg. Co., Inc. 84

Garlock, Inc. 90
General Aniline & Film Corp., Ozalid Div. 5
General Controls Co. 93
General Electric Co., Miniature Lamp Dept. 97
Grace & Co., W. R., Polymer Chemicals Div. 45
Greene, Tweed & Co. 108

Hamilton Mfg. Co., Drafting Equipment Div. 83
Handy & Harman 34
Hannifin Co., Div., Parker-Hannifin Corp. 101
Haveg Industries, Inc., Taunton Div. . 35

International Nickel Co., Inc. 2

Jarvis & Jarvis, Inc. 86

Kennametal, Inc., Metalworking Div. . 32

LaSalle Machine Tool, Inc. 100
Linde Co., Div. of Union Carbide Corp. 40-41
Link-Belt Co. 11
Lovejoy Flexible Coupling Co. 82

McGill Mfg. Co., Inc. 36
M-D Blowers, Inc., Subs. of Miehle-Goss-Dexter, Inc. 96
Mayline Co., Inc. 86
Mead Specialties Co. 94

National Tube Div., U. S. Steel Corp. 43
Nicholson & Co., W. H. 106
Northern Ordnance, Inc., Subs. of Northern Pump Co. 102

OPW-Jordan Co. 94
Ohio Nut & Bolt Co. 100
Ohio Rubber Co. 30

Palnut Co., Div., United-Carr-Fastener Corp. 92
Parker-Hannifin Corp., Hannifin Co., Div. 101
Perkins Machine & Gear Co. 105
Plastic & Rubber Products Co. 107
Precision Rubber Products Corp. 42

Racine Hydraulics & Machinery, Inc. . 89
Raybestos-Manhattan, Inc. 22-23
Manhattan Rubber Div. 22
Packing Div. 23
Adhesives Div. 23
Reuland Electric Co. 91
Robbins & Myers, Inc. 46-47
Rockford Clutch Div., Warner Corp. .. 28
Rockwood Sprinkler Div., Gamewell Co. 78

Speed Selector, Inc. 88
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp. 33
Stocker & Yale, Inc. 101
Stratoflo Products, Inc. 102

Timken Roller Bearing Co. ....4th Cover
Tinnerman Products, Inc. 52
Torrington Co., Bearings Div. 38

Unistrut Products Co., Rotocon Div... 82
United Electric Controls Co. 96
U. S. Graphite Co., Div. of the Wickes Corp. 18-19
U. S. Radium Corp. 104
U. S. Steel Corp., National Tube Div.. 43
Universal Electric Co. 10

Viking Pump Co. 94
Vulcan Rubber Products Div., Reeves Bros., Inc. 88

Wagner Electric Corp. 50
Waldron-Hartig Div., Midland-Ross Corp. 29
Watlow Electric Mfg. Co. 87
Weckesser Co. 98
Weirton Steel Co., Div., National Steel Corp. 37
Westinghouse Electric Co. 49

LLOYD R. LAWRENCE *advertising sales manager*
P. F. PRITCHARD *manager, market development*
THOMAS R. COASH *circulation*
RUSSELL T DOUGLAS *business manager*

ADVERTISING SALES STAFF

ATLANTA 9 . . . Ray K. Burnet, 1375 Peachtree St., N.E., Trinity 5-0523
BOSTON 16 . . . M. A. Williamson, Jr., McGraw-Hill Bldg., Copley Square, Congress 2-1160
CHICAGO 11 . . . Mid-Western Adv Sales Manager, A. E. Meanor; R. W. Bruley, L. Anderson, 520 N Michigan Ave, Mohawk 4-5800
CLEVELAND 13 . . . A. F. Tischer, 1164 Illuminating Bldg, 55 Public Sq, Superior 1-7000
DALLAS 1 . . . John Grant, 901 Vaughn Bldg, 1712 Commerce St, Riverside 7-5117
DENVER 2 . . . John W. Patten, Tower Bldg, 1700 Broadway, Alpine 5-2981
DETROIT 26 . . . P. B. Robinson, 856 Penobscot Bldg, Woodward 2-1793
HOUSTON 25 . . . Gene Holland, W-724 Prudential Bldg, Jackson 6-1281
LOS ANGELES 17 . . . Robert Obenour, 1125 West 6th St, Huntley 2-5450
NEW YORK 36 . . . B. K. Adams, F. J. McKinley, 500 Fifth Ave, Oxford 5-5959
PHILADELPHIA 3 . . . John B. Lewis, H. M. Nicholson, 6 Penn Center Plaza, Locust 8-4330
PITTSBURGH 22 . . . C. F. Leveroni, 4 Gateway Center, Express 1-1314
PORTLAND 4, ORE. . . . Scott Hubbard, 445 Pacific Bldg, Capitol 3-5118
ST LOUIS 8 . . . R. W. Bruley, 3615 Olive St, Continental Bldg, Jefferson 5-4867
SAN FRANCISCO 4 . . . W. C. Woolston, 68 Post St, Douglas 2-4600.

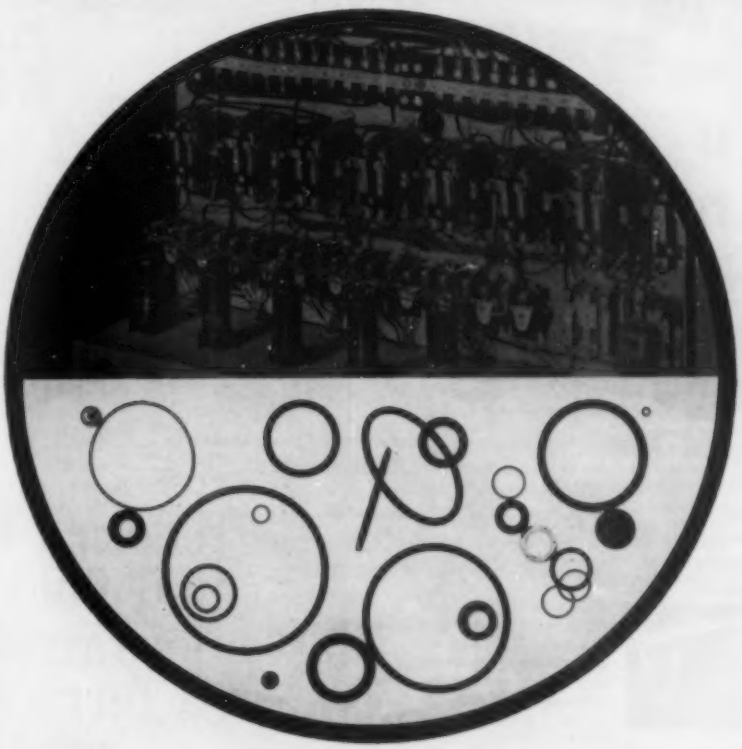
SUBSCRIPTIONS. Send subscription correspondence and change of address to Fulfillment Manager, PRODUCT ENGINEERING, 330 W 42nd St, New York 36, NY. Subscribers should notify Fulfillment Manager promptly of any change of address including postal zone number, if any. If possible, enclose an address label from a recent issue of the magazine. Since copies are addressed one to two issues in advance, please allow one month for change of address to become effective. Subscriptions are solicited only from executives, engineers and consultants engaged in the design of machinery and other engineered products. Position and company connection must be indicated on subscription orders.

OFFICERS OF THE PUBLICATIONS DIVISION: Nelson L. Bond, President; Shelton Fisher, Wallace F. Traendly, Senior Vice Presidents; John R. Callaham, Vice President and Editorial Director; Joseph H. Allen, Vice President and Director of Advertising Sales; A. R. Venezian, Vice President and Circulation Coordinator. **OFFICERS OF THE CORPORATION:** Donald C. McGraw, President; Joseph A. Gerardi, Hugh J. Kelly, Harry L. Waddell, Executive Vice Presidents; L. Keith Goodrich, Vice President and Treasurer; John J. Cooke, Secretary.

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.
EMPLOYMENT OPPORTUNITIES..... 102

PARCO PROBLEM PROBERS

???...HIGHEST QUALITY IN HUNDREDS OF THOUSANDS DAILY



!!! If production of your product design requires thousands of highest quality molded rubber parts every day, Parco's Parco-Matic Process is the answer. Parco's new, electronically controlled high-speed technique for producing molded rubber parts excells in maintaining constant high quality at the lowest possible cost. ◯ The Parco-Matic Process employs extremely accurate molds in which each unit is produced by an electronically controlled curing cycle employing exactly duplicated time and temperature constants from batch to batch. Because of mold accuracy, the products produced are essentially flashless and maintain consistent close tolerances. The last part molded in a long production run is an exact duplicate of the first and all parts in between when Parco-Matic is used. ◯ There is no room for error or variations with Parco-Matic. If you require large quantities of the highest quality molded rubber parts combined with production economies, let Parco-Matic solve your problem and reduce your costs.

Send for your latest Parco Slide Rule

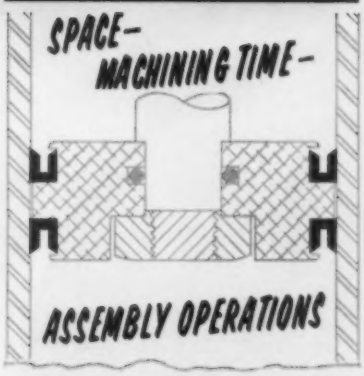
Plastic and Rubber Products Company
2100 Hyde Park Boulevard
Los Angeles 47, California

Plastic and Rubber Products Company
2100 Hyde Park Blvd. • Los Angeles 47, Calif.
Please send the Parco O-Ring Data Chart to:

NAME_____
COMPANY_____
BUSINESS ADDRESS_____
CITY_____
ZONE_____ STATE_____

CIRCLE 107 ON READER SERVICE CARD 107

PALMETTO® U-RINGS SAVE...



Now widely used where cup or V-packings were required, Palmetto U-Rings are effecting important savings for designers and builders of hydraulic and pneumatic equipment. Their compactness, versatility, strength and durability permits the use of simple, one-piece pistons . . . eliminates glands, backing plates, and their accessory fittings. Savings in space, machining time, and assembly operations are obvious.

Palmetto U-Rings seal with extremely low friction. There is no opportunity for binding due to over compression. Rugged, rectangular design Palmetto U-Rings (greater height than cross-section width), are more stable than square rings, resist rolling or twisting in piston groove.

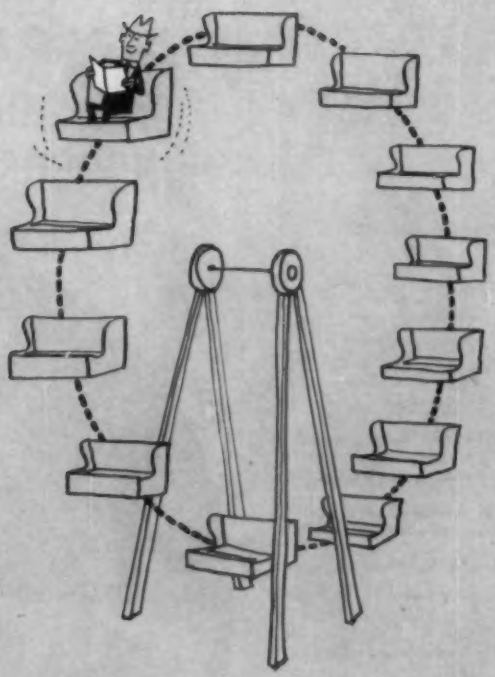
Palmetto fabric reinforced U-Rings are available for use where clearances are larger, pressures are higher, or greater strength is required, as in hydraulic service . . . Also available in homogenous rubber for use where clearances are smaller and where pressures are below 500 psi, as in air service. Both styles are designed to snap over a retaining lip and into the packing groove of simple one piece pistons.

SEND FOR THIS HELPFUL MANUAL

Just published, this useful literature has tables, specifications, recommendations and other data of interest to design men. Ask for your copy of UR-160. For any assistance — compound recommendations, design help –contact us immediately.

GREENE, TWEED & CO.

NORTH WALES, PA.



Frederick Krampf, noted child psychologist, enjoys reading in a ferris wheel.

"I like to surround a problem," he says. You'll be surprised how much faster your engineers and managers can solve their problems when you encourage them to do more reading that suits their special needs. Remember, a good place to read is a good place to think . . . and if you pay engineers and managers to think, encourage them to do more reading. Like so many successful men who read their "most useful" McGraw-Hill publications, they'll find the best place . . . home or plant, office or hammock. But wherever they read, remember, you share in the rewards.*

**Yes, when they read, you profit, too. Write on your business letterhead for a personal copy of booklet, "The McGraw-Hill Engineered Reading Program."*

PERSONAL READER SERVICE

USE ATTACHED CARDS FOR PERSONAL COPIES OF ADDITIONAL PRODUCT DESIGN DATA

. . . Data on Materials and Components
. . . Free Article Reprints
. . . New Catalogs and Bulletins
. . . Brochures on Advertised Products
. . . Personal Suscriptions to PRODUCT ENGINEERING

Valuable new data on product design engineering — readily available to you — FREE.

Just circle the numbers on the request cards that are identical with the numbers printed under each Advertisement, New Product and Bulletin throughout this issue.

Reprint numbers are prefaced with the letter "P". *One free reprint* is available for each article offered.

Issue of November 7, 1960
PRODUCT ENGINEERING
Card Expires January 6, 1961

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

22 FL

USE THIS CARD

to be sure to get your personal subscription to PRODUCT ENGINEERING sent each week to your home or office.

Now only $3 per year (U.S.A.)

Issue of November 7, 1960
PRODUCT ENGINEERING

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

22 FL

ADD TO YOUR DESIGN REFERENCE FILE FROM

EDITORIAL REPRINTS AVAILABLE

(Single reprints free, additional copies 6 for $1)

P40—ELLIPTICAL GEARS
For cyclic speed variations; useful design equations, examples.

P46—INTEGRAL BALL BEARINGS
New approach to product improvement, longer bearing life or higher loads.

P49—ANALOG FOR HEAT FLOW
Electrical simulator predicts heat flow under complex conditions.

P50—WEAR OF ROLLING SURFACES
New equations give life expectancy for gears, cams, bearings.

P51—PNEUMATICS SIMULATES ELECTRONICS
Dimensional analysis of all units needed in control service.

P52—SELECTING SOLENOIDS
A guide to ac or dc, and linear or rotary types.

P53—LIGHT-DUTY BELT DRIVES
Performance compared for all five basic types.

P54—EPICYCLIC GEAR SYSTEMS
Modified equations give volume, power capacity, speed ratios, stresses.

(please print or type)

Name.....Title.....

Street.....

City.....Zone.....State.....

Company.....Major Product Manufactured.....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS
P40 P46 P49 P50 P51 P52 P53 P54 P56
P58 P59 P60 P61 P62 P63 P64 P65 P66

*MULTIPLE Key No.	PRODUCT ADS Specific Product

TAKE ADVANTAGE OF NEW LOW PRICE!

Have your own personal subscription to PRODUCT ENGINEERING sent each week to your office or home. You are then sure that you won't miss a single weekly issue. Further, each year of your subscription you will have your copy of the annual, thick Design Digest issue to read and refer to for years to come.

☐ 1 year—NOW $3 U.S. only* ☐ 2 years—NOW $4

*Canada
1 year—$5
2 years—$8

☐ Payment enclosed

☐ Bill me

Name .....Title .....

Home ☐ .....

Address Office ☐ ..... Dept.....

City .....Zone .....State .....

Company Name .....Product Mfgd.....

P56—TAPERED CANTILEVER BEAMS
How to calculate stresses and deflections for five sections.

P58—STRONG ALUMINUM ALLOYS
How the new X2020 stacks up with other high-strength alloys.

P59—THE RESPONSE EQUATION
Some graphical tricks that eliminate tedious slide rule work.

P60—ACCELEROMETER
Evaluation of all types suitable for control applications.

P61—DIMENSIONAL STABILITY IN PRECISE PARTS
How properties change under stress and heat.

P62—FRICTION COEFFICIENTS
Complete table; how to adapt values to actual service.

P63—QUICK-CONNECT COUPLINGS
For hydraulic and pneumatic systems; basic types and variations.

P64—BENDING GAGE
New strain gage system measures from one side of section.

P65—HELICAL GEARS
How to change pitch diameter by varying pitch angle.

P66—SLIDERULES
Get more from your sliderule shortcuts to solution of complex problems to greater accuracy.

NEW CATALOGS AND BULLETINS

METALS AND ALLOYS

363—Alloy Iron Properties, 8 pp, Shenango Furnace Co.

NON-METALLIC MATERIALS, FINISHES

353—Custom-produced Glass, 16 pp, Kopp Glass Inc.

POWER TRANSMISSION

358—Mechanical - power - transmission Equipment, 8 pp, T B Wood's Sons Co.

366—Miniature Precision Differentials, 4 pp, Empire Flight Components Inc.

MECHANICAL PARTS

350—Wheels and Casters, 75 pp, Colson Corp.

357—Spring Materials, kit, H K Porter Co Inc, Riverside-Alloy Metal Div.

368—Mechanical Shaft Seals, 4 pp, Syntron Co.

FASTENING AND JOINING

351—Mounting Techniques, 72 pp, TA Mfg Co, Engineering Dept.

THIS WEALTH OF VITAL INFORMATION . . .

NEW COMPONENTS

GENERAL ENGINEERING

330—High-volume Whiteprinter
331—Vertical Blueprint File

RESEARCH AND TEST EQUIPMENT

321—Pressure-gage Accessories
332—Servo Development Kit

METALS AND ALLOYS

310—Air-hardening Tool Steel
315—Aluminum Oxide Insulated Wire

NON-METALLIC MATERIALS, FINISHES

301—Parts Molded of Filled Silicone
304—Teflon Film Is Cementable

FABRICATION PROCESSES AND PRODUCTION

307—Impact Extrusion Process
326—Rotary Bin Activator
329—Heavy-duty Bin Vibrator

POWER TRANSMISSION

327—4-speed Auxiliary Transmissions

MECHANICAL PARTS

313—12- and 24-hr. Clocks

FASTENING AND JOINING

307—Impact Extrusion Process

MOTORS, ENGINES AND CONTROLS

309—Low-speed Indicator
332—Servo Development Kit

ELECTRICAL, ELECTRONIC COMPONENTS

300—Modular Block-type Reader
306—Snap-action Pushbutton Switches
311—Frequency-to-analog Transducer
314—Multiple Programming Sequences
315—Aluminum Oxide Insulated Wire
316—Fuse Filament Is Vacuum-sealed
320—Incandescent Indicator Light
322—Low-cost Ac Panel Meter
323—High-performance Switch
324—Acrylic Plastic Front Meter
325—Environmental Connector

HYDRAULIC, PNEUMATIC EQUIPMENT

302—Pressure Measurement Device
303—Vernier Pressure Regulator
305—Solenoid Plunger and Poppet
308—1-in. Bore Air Cylinders
312—Fingertip Control Valves
317—Pressure Gage Protector
318—Automatic Drain Air Filter
319—Compressed Air Filters
321—Pressure-gage Accessories
328—Remote Control Valves

ELECTRICAL, ELECTRONIC COMPONENTS

352—Electronic Controls, 24 pp, Autotron Inc.

359—Transistor-equipped Temperature Controls, 8 pp, Fenwal Inc.

360—Receiver Gages, 8 pp, American Machine & Metals Inc, US Gauge Div.

361—Printed Circuit Board, 2 pp, Elgin Laboratories Inc.

362—Miniature Transformers, 24 pp, Microtran Co Inc.

364—Rocker-type Footswitches, 2 pp, Linemaster Switch Corp.

365—Door Interlock Switches, 2 pp, Micro Switch

367—Braiding Products, 4 pp, Alpha Wire Corp.

HYDRAULIC, PNEUMATIC EQUIPMENT

354—Fluid Accumulators, 23 pp, Hale Fire Pump Co, Fluid Power Div.

355—Cylinder Force Calculation, chart, Sheffer Corp.

356—Plastic Valves and Fittings, 16 pp, Walworth Co.

(please print or type)

Name..... Title.....

Street.....

City..... Zone..... State.....

Company..... Major Product Manufactured.....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS

P40	P46	P49	P50	P51	P52	P53	P54	P56
P58	P59	P60	P61	P62	P63	P64	P65	P66

*MULTIPLE Key No.	PRODUCT ADS Specific Product

(please print or type)

Name..... Title.....

Street.....

City..... Zone..... State.....

Company..... Major Product Manufactured.....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS

P40	P46	P49	P50	P51	P52	P53	P54	P56
P58	P59	P60	P61	P62	P63	P64	P65	P66

*MULTIPLE Key No.	PRODUCT ADS Specific Product

USE THESE PREPAID CARDS FOR

- More information on advertised products
- More data on new materials and components
- Copies of catalogs and bulletins offered
- Free editorial reprints
- Your personal subscription to PRODUCT ENGINEERING

Issue of November 7, 1960
PRODUCT ENGINEERING
Card Expires January 6, 1961

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

22 FL

Issue of November 7, 1960
PRODUCT ENGINEERING
Card Expires January 6, 1961

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

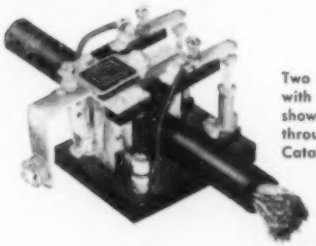
PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

22 FL

Information Sent Promptly

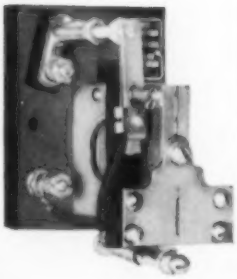
An Opportunity To Get More Information Quickly, Conveniently

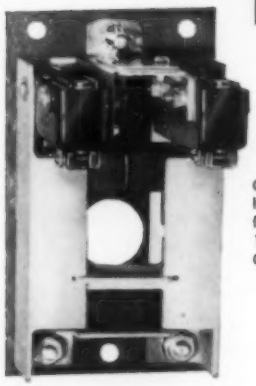
unique ASCO current type relays operate without a coil on A-C or D-C



Two Pole Coil-less Relay with Counterbalance, showing how cable passes through Relay. ASCO Catalog No. 15130.

Relay used to measure KVA in single phase 3 wire system by passing live line cables through the relay in opposite directions. Relay adjusted to pickup at 27.2 KVA and dropout at 20.5 KVA. ASCO Catalog No. 15135A.





Coil-less Relay designed for high frequency induction furnace application to 10,000 cycles. ASCO Catalog No. 15144.

ASCO Current Type Relays are designed to function like current transformers. The load cable through the relay provides the magnetic field for operation. The broad range of adjustments available in these relays, along with their versatility and power relay construction, has stimulated design engineers wherever current sensing relays are required.

FEATURES

• Ease of installation—cable passes through relay — does not have to terminate at relay • Pick up at relatively low currents assured by highly efficient magnetic circuit • Long life and low maintenance costs provided by Oilite bearings • Available for either A-C or D-C control • Pure silver contacts • May be mounted in any position without affecting relay operation when equipped with counterbalance • Load cable up to ⅞" O.D. securely positioned by guide plate.

APPLICATIONS

ASCO Coil-less Relays are used primarily for continuous welding operations. When so applied the load cable connected to the welding electrodes passes through the relay. Then as a function of the welding current the relay operates to control the motor feeding the material to be welded. These relays are also useful as instantaneous response overcurrent relays. For example, they have been used to sense overcurrent in both branches of a single phase, three wire system by passing both live line cables through the relay in opposite directions. In function this arrangement produces a KVA response relay.

Coil-less Relays are only a part of the complete line of Relays offered by ASCO. ASCO Catalog 57-S4 lists:

- MAGNETICALLY HELD RELAYS AC or DC . . . Normally Open . . . Normally Closed . . . Double Throw
- MAGNETICALLY HELD RELAYS AC or DC . . . All pole combinations
- SPECIALIZED RELAYS, INCLUDING:
  - . . . Reverse Current
  - . . . Time Delay
  - . . . Close Differential
  - . . . Brake Winding Time Delay
  - . . . Electronic
  - . . . Modified Arrangements

ASCO Valves

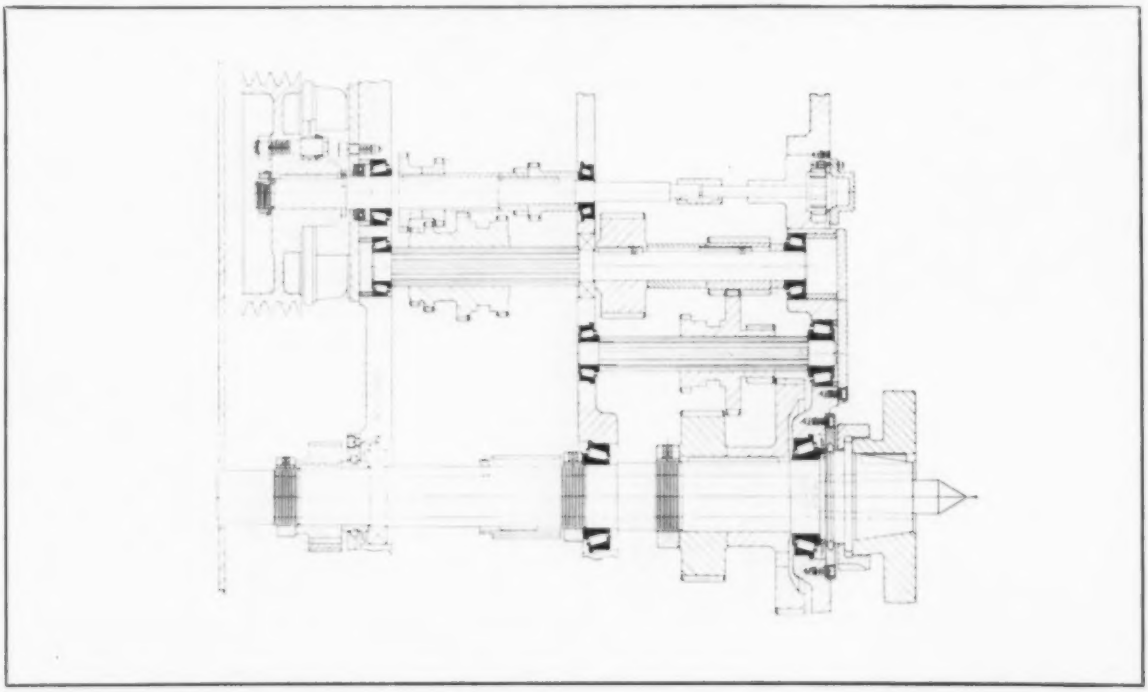
Automatic Switch Co. 54G HANOVER RD., FLORHAM PARK, N. J., FRONTIER 7-4600

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

ASCO

CIRCLE 202 ON READER SERVICE CARD

LeBLOND lathe obtains super spindle-runout of less than .000025″ with Timken® "00" bearings



To raise the already great precision of its 15″ Dual-Drive lathe to a special new high for a customer, LeBlond had to meet this requirement: spherocity of the part to be turned—a beryllium gyro float assembly—had to be concentric with its two major axes within .0005″ total indicated runout. Diameter of the sphere: 1.8750″.

To assure this, LeBlond engineers specified Timken® super-precision "00" tapered roller bearings held to .000025″ assembled runout for the spindle—one-third the normal runout tolerance for these bearings. Timken bearings were also used on the intermediate, back and feed shafts of the drive. The assembled spindle runout (total indicator reading) was actually less than .000025″.

Producing super-precision bearings like this is typical of Timken Company service. The kind of service that developed Timken "00" bearings to meet industry's needs for ever-greater precision. It's another example of the Timken Company's leadership in tapered roller bearing design and manufacture.

YOUR BEARING PROBLEMS can often be solved on-the-spot by our graduate engineer salesmen. Working with you at the design stage, they can help you select the Timken bearing to meet your special needs, save you time and money.

Industry rolls on

TIMKEN®

tapered roller bearings

The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO." *Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.* Canadian Division: Canadian Timken, St. Thomas, Ont.

CIRCLE 203 ON READER SERVICE CARD